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USAAVCOM PROJECT NO. 67-26 (66-06)
USAAVNTA PROJECT NO. 67-26 (66-06)

ENGINEERING FLIGHT TEST OF THE AH-1G (HUEYCOBRA) HELICOPTER EQUIPPED WITH THE XM-28 CHIN TURRET WITH TWIN XM-134 MINIGUNS

PHASE B

PART 3

FINAL REPORT

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MARCH 1968

US ARMY AVIATION TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

Statement 4 per Mr. Homyer (for Col Robt R Corey). Monitor: Army Materiel Command, attn: AMCPM-IR, Washington, D.C. 20315. A Healy
26 June 68

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834379

DEPARTMENT OF THE ARMY
U.S. ARMY AVIATION SYSTEMS TEST ACTIVITY
Edwards Air Force Base, California 93523

SAVTE-AS 4 March 1969

SUBJECT: Change Number 1 to the USAAVNTA Project No. 67-26 (66-06) Final Report.

SEE DISTRIBUTION

1. In accordance with unclassified message 12-1331 from AMSAV-R-FT, subject: AH-1G Phase B Test Reports - Control Positions, 13 December 1968, the following pen and ink changes will be made:

Engineering Flight Test of the AH-1G (HUEYCOBRA) Helicopter Equipped with the XM-28 Chin Turret with Twin XM-134 Miniguns, Phase B, Part 3, March 1968, appendix IV (pg 29).

Was: **Main Rotor:**		
	Collective pitch travel	7.29 deg
	Longitudinal cyclic travel	±14 deg
	Lateral cyclic travel	±10 deg
Now: **Main Rotor:**		
	Collective:	
	Pitch full travel	8.63 in.
	Stick:	
	Longitudinal full travel	9.29 in.
	Lateral full travel	9.29 in.
Tail Rotor:		
	Directional:	
	Pedal full travel	5.86 in.

2. After the above change has been posted, this letter will be filed with the subject report.

FOR THE COMMANDER:

1 Incl
Distribution

GERALD T. YAHIRO
CPT, INF
Acting Adjutant

1473

16 RDTE-[redacted] 1X141807D174,
USAAVCOM-[redacted] 67-26 [redacted]
~~USAAVNTA PROJECT NO. 67-26 (66-06)~~

6 ENGINEERING FLIGHT TEST OF THE AH-1G (HUEYCOBRA) HELICOPTER EQUIPPED WITH THE XM-28 CHIN TURRET WITH TWIN XM-134 MINIGUNS. PHASE B. PART 3.

9 FINAL REP[redacted]T. 20 Oct-28 Dec 67,

10 JOHN R. MELTON
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11 MAR[redacted] [redacted]68

12 49p.

STATEMENT #4 UNCLASSIFIED

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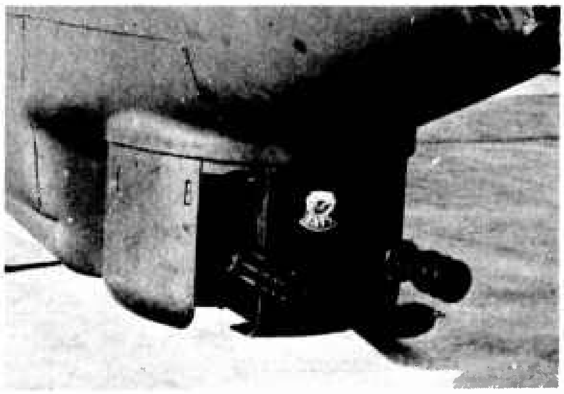
attn: AMCPM-IR, Wash. D.C. 20315

US ARMY AVIATION TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

MSL(036470)

FOREWORD

During the conduct of the AH-1G Helicopter Phase B, Part 3, test at Yuma, Arizona, maintenance of the helicopter, maintenance of special instrumentation, and data reduction assistance was provided by Bell Helicopter personnel under contract. US Army firing ranges, hangar and office facilities were utilized at Yuma Proving Ground, Arizona.



ABSTRACT

Part 3 of the AH-1G helicopter Phase B test was conducted at Yuma Proving Ground, Yuma, Arizona from 27 November to 1 December 1967 by the US Army Aviation Test Activity, Edwards AFB, California. Firing tests were conducted to determine the effects on the stability and control characteristics of the AH-1G helicopter caused by firing the twin XM-134 minigun 7.62 machine guns in the XM-28 chin turret. Firing the two XM-134 miniguns in the XM-28 turret does not cause any objectionable aircraft reactions which would restrict the flight envelope. The deficiencies detected during this test were lack of fire warning system, unreliability of the roll pins on the feeder assembly, use of a quick disconnect on the gun end of the crossover drive, excessive ammunition chute flexure during loading, and requirement to arm weapons to drop smoke grenades. Shortcomings detected during this test were latches on the ammunition chute adapters which were too small, flex sight interference with gunner's right leg when sight was stowed, functional switches mislocated and unguarded on flex sight, two position trigger switch not sufficiently distinct between high and low rate, cord for headphone jack in pilots cockpit too long, lack of hand holds for rotor hub inspection, insufficient nonskid material on wings, lack of static droop stops, and lack of quick release fasteners for tail rotor gear box and oil cooler inlet fairings.

TABLE OF CONTENTS

INTRODUCTION

BACKGROUND

1. The XM-28 chin turret was originally scheduled for test by the US Army Aviation Test Activity (USAAVNTA) on AH-1G Helicopter S/N 66-15250 equipped with the twin XM-129, 40 mm grenade launchers (ref 1, app I). This configuration was considered to be more critical than the twin XM-134 minigun, 7.62 mm machine gun configuration, and therefore, would be the only configuration tested. To expedite development of the XM-28 in both the twin XM-134 and twin XM-129 configurations, it was determined that AH-1G helicopter S/N 66-15283 would be used to develop the twin XM-134 configuration while AH-1G helicopter S/N 66-15250 would be used for development of the twin XM-129 configuration. Due to difficulties encountered in the development phase of the twin XM-129 configuration, early completion of the twin XM-134 configuration and imminent XM-28 deployment dates it was decided to perform the airworthiness qualification and USAAVNTA tests on the XM-28/XM-134 configuration on AH-1G helicopter S/N 66-15283 while development of the XM-28/XM-129 continued on AH-1G helicopter S/N 66-15250 (ref 2 and 3, app I). This would allow the XM-28/XM-134 configuration to be deployed if the twin XM-129 was not qualified on time. The results of the test of the XM-28/XM-134 configuration are included in this report. The XM-28/XM-129 configuration will be tested by USAAVNTA on AH-1G helicopter S/N 66-15283 after completion of the XM-28/XM-129 airworthiness qualification (ref 2 and 3, app I). The XM-28/XM-129 test report will be submitted under separate cover as Phase B, Part 4.

TEST OBJECTIVES

2. The objectives of this test were to provide flight test data to:

a. Assist in determining if the contractor's proposed flight envelope should be used by Army pilots for future service tests, logistic tests, or operational tests.

b. Define and allow early correction of helicopter and weapons system deficiencies.

c. Provide a basis for evaluation of changes incorporated to correct deficiencies.

d. Estimate the degree to which the helicopter and weapons system is suitable for the intended mission.

DESCRIPTION

3. The test aircraft serial number 66-15283, was the thirty-ninth AH-1G, Hueycobra, Tactical Helicopter produced by Bell Helicopter Company designed specifically for the armed role. It is a tandem, two-place, high speed conventional helicopter with a two-bladed door hinge type main rotor and conventional antitorque rotor. A three-axis stability and control augmentation system (SCAS) is used in lieu of the stabilizer bar to improve helicopter stability and handling qualities. The test helicopter is powered by a Lycoming T53-L-13 turboshaft engine rated at 1400 shaft horsepower (shp) at sea level (SL) standard day static conditions. The powerplant is derated to 1100 shp at 314 rpm rotor speed due to maximum torque limits of the helicopter main transmission. The distinctive features of the test helicopter are the narrow 36-inch fuselage, the stub mid-wings with four external stores stations, and the integral XM-28 chin turret The XM-28 chin turret on the test helicopter contained two XM-134 miniguns as opposed to the original AH-1G chin turret, the TAT102A which contained one minigun. The turret can position the weapon 115-degrees left and right of the stow position. Weapon elevation is variable from 15 to 25 degrees, depending on the azimuth position of the turret. Weapon depression is 50 degrees at all azimuth positions. The XM-28 turret is designed to accomodate twin XM-134 miniguns, or twin XM-129, 40 mm grenade launchers, or one minigun and one 40 mm grenade launcher. The armament configuration of the AH-1G is changed by varying wing stores and/or turret weapons. The pilot can fire all weapons in the stowed position. The copilot/gunner operates the flexible turret and can also fire wing stores in an emergency by use of the pilot override switch. The flight control system is a positive mechanical type with conventional helicopter controls in the pilot's aft cockpit. The copilot/gunner's forward cockpit is provided with sidearm collective and cyclic controls. Control forces are reduced by hydraulic servo cylinders connected to the control system mechanical linkage. The hydraulic system is powered by dual transmission-driven pumps. A synchronized elevator is used to increase static longitudinal stability and lengthen center of gravity (C.G.) range. An electrically operated mechanical force trim system connected to the cyclic and directional controls is used to induce artificial control feel and positive control centering. Ausform armor protection is provided for the crew, engine fuel control, and engine compressor section. A complete aircraft description is included in reference 4 and 5, appendix I, and aircraft dimensions and design information are presented in appendix IV.

SCOPE OF TEST

4. This test program consisted of an investigation of the affects on the stability and control characteristics of the AH-1G helicopter caused by firing the twin XM-134 minigun,7.62 machine guns,in the XM-28 chin turret. Both XM-134 miniguns were fired simultaneously at the test conditions shown in Tables 1 and 2. Five flights were conducted for a total of 5.5 test hours during an elapsed calendar time of four days. The flight restrictions which governed these tests were obtained from a safety-of-flight release issued by US Army Aviation Materiel Command (USAAVCOM), St. Louis, Missouri (ref 6, app I), and are presented in appendix V. Approximately 18,000 rounds of 7.62 mm ammunition were expended during the test.

Table 1. Turret Positions.

Position Number	Turret Elevation	Turret Azimuth
1	Full up	90° left
2	Full up	Zero
3	Full up	90° right
4	Full down	90° right
5	Full down	Zero
6	Full down	90° left
7	Zero	90° left
8	Zero	Zero
9	Zero	90° right

Table 2. XM-28 Flight Test Conditions.

Airspeed KCAS	Turret Position from Table 1.
Hover	1, 2, 3, 7, 8, 9
60	2, 5, 8
128	1, 2, 3, 5, 6, 7, 8, 9
176	1, 2, 3, 4, 6, 7, 8, 9

Test gross weight was between 8010 pounds and 8660 pounds.

Test center of gravity was between 198.5 in. and 202.3 in.

Instrumentation pods, which are aerodynamically similar to the XM 159 rocket pod, were installed on outboard wing stations.

Density altitude was between 1160 feet and 2600 feet.

Rotor speed was 324 rpm.

METHOD OF TEST

5. The method used in this test was a standard engineering flight test method and is described briefly in the Results and Discussion Section of this report.

CHRONOLOGY

Test directive received	20 October 1967
Test helicopter received at Yuma, Arizona	27 November 1967
Test started	28 November 1967
Test completed	30 November 1967
Draft report submitted	28 December 1967
Final report forwarded	MARCH 1968

RESULTS AND DISCUSSION

GENERAL

6. This section of the report presents a detailed discussion of the results of the test. The subjects covered are cockpit evaluation, firing tests, miscellaneous (weapons and maintenance problems) and airspeed calibration.

COCKPIT EVALUATION

Pilot's Cockpit

7. There were two objectionable characteristics noted in the pilot's cockpit. The cord for the headphone jack was entirely too long and became entangled with the collective pitch stick on several occasions. This could cause an unsafe condition if it occurred in flight and it should be corrected. Secondly, the XM-20 smoke grenade dispenser cannot be operated unless the master arm switch is in the "armed" position. Since the smoke grenade dispenser will be required to mark friendly positions it should be capable of being operated while the firing circuits of the weapons systems are in a safe condition. The armament panel should be revised to permit operation of the XM-20 smoke grenade dispenser in both the "safe" and "armed" positions of the master arm switch. The XM-28 fire control system logic and switching arrangements are greatly improved over the TAT102A. Most of the deficiencies and shortcomings found in the TAT102A have been corrected on the XM-28 chin turret.

Copilot/gunner's Cockpit

8. The flexible copilot/gunner's sight for the XM-28 turret provided an adequate range of travel and caused no interference with copilot/gunner's torso. The flexible sight was well balanced permitting ease of operation. When stowed on its mount, the sight forced the copilot/gunner into an uncomfortable position due to interference with the right leg. Right pedal control was very uncomfortable, although full pedal and positive control of the aircraft could be maintained. Two functional switches were located on the sight which should be relocated to the gunner's armament control panel. The lead angle compensation selector was located in an area that was difficult to see and could be accidently actuated. The selector switch for left, right, or both guns was an unguarded toggle switch mounted in an exposed position on the face of the sight. During this limited evaluation, when the selector was in

the "both" position it was accidently moved to the left gun position while tracking with the flexible sight. This switch should be guarded as a minimum, and preferably relocated to the copilot/gunner's control panel.

9. High or low rate of fire is selected by a detent in the index finger operated two position trigger. Low rate is selected at the first position and high rate at full trigger depression. On the test article, the two positions were not sufficiently distinct to allow the copilot/gunner to consistently select low rate of fire. A more positive feel for the two positions of the trigger should be provided.

FIRING TEST

10. Firing tests were conducted to determine the effect on the stability and control characteristics of the helicopter caused by XM-28/XM-134 firing. The helicopter was stabilized on the desired trim conditions and all flight controls were held constant during the firing tests. As the guns were fired the pilot's controls were held fixed. The oscillograph was actuated to record attitude changes, and rates about the three axes caused by firing of the weapons. All tests were conducted with both guns operating at high rate since this was considered to be the most critical condition.

11. Figures 1 through 11, appendix II, present the results of the XM-28 firing tests. Figures 1 through 3 summarize the reactions of the helicopter about each axis as a function of airspeed, turret elevation and turret azimuth. Figures 4 through 11 present aircraft reaction while firing at selected conditions.

12. Pitch axis reactions, summarized in figure 1, appendix II were generally very small. The maximum pitch rate attained during a three to five second high rate burst with controls fixed was 4.5 deg/sec nose down. This rate was produced in a hover with the turret at full up elevation. At increased airspeed, all pitch reactions were decreased. Aircraft reactions in the pitch axis were not significantly affected by turret azimuth, but only by turret elevation. The direction of pitch reaction depended upon turret elevation. Full up elevation produced a nose down reaction and full down elevation produced a nose up reaction. With the turret in the stowed position, pitch reaction was very small at all conditions. This is the position from which the pilot would fire the turret as a fixed weapons system. With fixed controls, the reactions were so small that they approached the limits of readability of the instrumentation. With practice, a pilot could learn to anticipate and correct for this small reaction with corrective control inputs.

13. Roll axis reactions are summarized in figure 2, appendix II. Roll reactions were not significant at zero azimuth and were a maximum at 90-degrees left or right azimuth. The turret was located below the C.G., causing the roll reaction to be in the same direction as turret azimuth. Firing to the right resulted in a right roll. The maximum roll rate attained during firing a three to five second high rate burst with controls fixed was 9.5 deg/sec right. This rate was produced at 176 knots calibrated airspeed firing at 90-degrees right azimuth. In general, roll axis reactions were greater to the right than to the left. At the same turret azimuth, roll reactions were slightly greater for up elevations than for down elevations. The magnitudes of the roll axis reactions were not objectionable, however, the characteristic of the reaction would be objectionable if the reaction were larger. At high speed and/or high shaft horsepower conditions the AH-1G basic airframe exhibits a roll oscillation with a frequency between approximately one-half to one cycles per second (cps) (ref 7, app I). When this oscillation is present or when the full capability of the SCAS is used to damp the oscillation, the roll reaction to firing initiates an oscillatory response. Target tracking then becomes somewhat more difficult than if the response were uniform. Figures 10 and 11 illustrate this oscillatory roll rate response with turret azimuth 90-degrees left and 90-degrees right at 176 KCAS. At zero turret azimuth, or stowed position, this response was not present. For short bursts, this oscillatory response is not significant because of its relatively long period. This roll axis oscillation is not unique to weapons firing. It is present at some flight conditions regardless of whether the turret weapons are being fired or not. A pilot soon becomes "tuned" to this frequency and learns to damp the oscillation with small periodic control inputs, which tend to decrease the target tracking task of the copilot/gunner.

14. Yaw axis reactions are summarized in figure 3, appendix II. These reactions were not significant at zero turret azimuth. At 90-degrees left or right azimuth, the reactions were maximum but were not objectionable at any conditions. The yaw axis reactions approached the limits of accuracy and readability of the instrumentation. The direction of the yaw reaction was opposite turret azimuth. Firing to the right resulted in a left yaw. For the same turret azimuth, turret elevation had very little effect upon the maximum yaw rate produced. With controls fixed, the aircraft assumed a new trim sideslip angle and yaw attitude as positive directional stability of the helicopter balanced weapons reaction at the turret. The yawing motion was quite smooth and should present no particular target tracking problem to the copilot/gunner.

MISCELLANEOUS

15. Three major stoppages of the left XM-134 minigun occurred on the first test day due to feeder problems. The feeder on the left weapon was old as compared to the right feeder and had suffered numerous jams during development and qualification phases of the contractor's test program. Left feeder operation was acceptable after replacing the roll pins. Sixteen thousand rounds were fired on the second test day with only one stoppage when the flexible shaft for the crossover drive became disconnected at the weapon. To improve reliability in the field, consideration should be given to establishing a replacement schedule of all feeder roll pins based on the number of hard feeder jams encountered. The contractor recommended replacement of pins after three hard jams. To avoid disconnects of the flexible shaft for the crossover drive at the gun end, a screw type adapter should be used in lieu of the present quick disconnect type.

16. A chute guide should be provided on the ammunition can lid to support the flexible chuting when the can is being inserted into the ammunition bay. The purpose of the guide would be to prevent flexure and damage of the chuting, weapon stoppages, and turn-around delays during rearming operations.

17. The present latches on the production ammunition chute adapters are too small and difficult to operate by hand, especially with gloves on. These latches should be made larger as on the production TAT102A and prototype XM-28.

18. Screws are still being used to attach the tail rotor fairing even though USAAVNTA recommended replacement by quick release fasteners early in the AH-1G development program. Quick release fasteners would greatly facilitate daily inspection of the 90-degree gear box and mount casting.

19. It is difficult to inspect the rotor head and mast because of the lack of hand holds. This shortcoming was previously reported by USAAVNTA and has not been corrected.

20. Sixty percent of the nonskid material which appeared on the upper surface of the prototype stub wings has been eliminated on this production helicopter. Without adequate nonskid material on the stub wings, inspection and maintenance from this position is potentially hazardous.

21. No engine fire warning system, considered a safety of flight item, is provided on production AH-1G helicopters. This system is

required, because of the mission of the aircraft, the lack of visibility aft, and the fact that live ordnance is carried.

22. No droop stops are provided on the rotor head to prevent mast damamge. The test helicopter showed some mast scoring that did not appear to be beyond acceptable limits. Static droop stops should be provided, since unacceptable damage had occurred on helicopter S/N 66-15247 that required mast replacement.

23. The oil cooler air inlet (left hand screened panel) should be secured by quick release fasteners instead of screws. This would facilitate daily inspection of the throttle linkage, electrical wiring and oil cooler.

AIRSPEED CALIBRATION

24. An airspeed calibration was conducted at a gross weight of 8290 pounds, C.G. location of 199.1 inches (aft) and a rotor speed of 324 rpm. The helicopter was paced by a T-28B airplane with two calibrated boom airspeed systems to determine position errors of the standard ships airspeed system. Position error was defined between the calibrated airspeeds of 92 and 185 knots. Since a trailing bomb was not available and only a very limited amount of testing was done between a hover and 100 knots calibrated airspeed, it was not considered practical to expend time calibrating the system by any other method through the low speed range. The results of the airspeed calibration tests are presented in figure 12, appendix II.

25. The magnitude of the airspeed position error at high airspeed was smaller than that of a similar AH-1G Helicopter previously tested by this Activity (ref 7, app I). At 180 knots indicated airspeed (corrected for instrument error), the position error of this system was -5.5 knots. At the same indicated airspeed, the position error from reference 7 was approximately -8 knots. Additional testing of production AH-1G aircraft will be necessary to accurately define the position error for production helicopters.

CONCLUSIONS

GENERAL

26. The following conclusions were reached upon completion of firing tests of the XM-28/XM-134 installed on the AH-1G Helicopter.

a. No objectional flight characteristics were encountered throughout the AH-1G flight envelope as a result of firing the XM-134 miniguns from the XM-28 turret (para 11 - 15).

b. The airspeed calibrations accomplished to date do not fully define the position error for production AH-1G helicopters (para 25).

DEFICIENCIES AND SHORTCOMINGS AFFECTING MISSION ACCOMPLISHMENT

27. Corrections of the following deficiencies are mandatory for acceptance of the aircraft weapon system.

a. The lack of an engine fire warning system is a hazardous deficiency of current production AH-1G helicopters (para 21).

b. The roll pins in the ammunition feeder on the XM-134 minigun became damaged after several hard feeder jams and caused numerous stoppages (para 15).

c. The flexible shaft for the crossover drive can become disconnected at the gun causing a stoppage (para 15).

d. Weapon stoppage and delayed turn around for reloading have resulted from chute flexure and damage during insertion of the ammunition can into the ammunition bay. The flexure and damage were caused by a lack of an ammunition chute guide on the ammunition can lid (para 16).

e. The XM-20 smoke grenade dispenser can only be operated when the master arm switch is in the "armed" position (para 7).

28. Correction of the following shortcomings is desirable for improved operation and mission capabilities.

a. The production XM-28 ammunition chute adapters have latches which are too small to be operated by hand, expecially with gloves on (para 17).

b. When stowed on its mount, the flexible copilot/gunner's sight forced the copilot/gunner into an uncomfortable position because of interference with his right leg (para 8).

c. The lead angle compensation selector and left, right or both gun selector switches were unguarded and located where they could be accidentally actuated (para 8).

d. It was difficult to distinguish between the positions of the two position trigger switch. This made it difficult to consistently select the desired rate of fire (para 9).

e. The cord for the headphone jack is too long and can become entangled around the collective pitch control (para 7).

f. The lack of hand holds makes inspection of the rotor head and mast difficult (para 19).

g. The test helicopter had a reduced amount of nonskid material (as compared to the prototype model) making the stub wing hazardous as a work platform (para 20).

h. The lack of static droop stops permits damage to the mast (para 22).

i. The tail rotor fairing is secured by numerous screws making daily inspection of the 90-degree gear box and mount casting more difficult and time consuming (para 18).

j. The oil cooler inlet panel is secured by screws which make daily inspection of the throttle linkage, electrical wiring, and oil cooler more difficult and time consuming (para 23).

RECOMMENDATIONS

29. A safety-of-flight release should be issued by the appropriate agency authorizing firing of the XM-28 turret with twin XM-134 miniguns at any conditions within the AH-1G operating limitations (para 11 - 15).

30. An engine fire warning system be provided on the AH-1G helicopter as a safety-of-flight requirement (para 21).

31. A replacement schedule of all feeder roll pins be established based on the number of hard jams experienced (para 15).

32. The quick disconnect type fitting on the gun end of the crossover drive flexible shaft be replaced by a screw-on type fitting (para 15).

33. An ammunition chute guide on the ammunition can lid be provided to support the flexible chuting during landing operations (para 16).

34. The master arm switch be rewired to allow operation of the XM-20 grenade dispenser in both the "SAFE" and "ARMED" positions (para 7).

35. Larger latches on the ammunition chute adapters be provided to facilitate hand operation (para 17).

36. The flexible sight be stowed in such a manner that it does not interfere with the copilot/gunner's right leg (para 8).

37. The lead angle compensation selector and gun selector switches be relocated to the armament control panel (para 8).

38. The two positions of the twin position trigger switch be made more distinct (para 9).

39. The cord for the headphone jack be shortened to avoid interference with the collective pitch control stick (para 7).

40. Hand holds be provided to facilitate access to the rotor hub and mast for inspection (para 19).

41. Maximum practical area of nonskid material at the root of the stub wings be provided for safe use of the wing as a work platform (para 20).

42. Static droop stops be provided on the rotor head to prevent mast damage (para 22).

43. The screws in the tail rotor fairing be replaced by quick release fasteners to facilitate maintenance and inspection of those items (para 18).

44. The screws in the oil cooler inlet panel be replaced by quick release fasteners to facilitate maintenance and inspection (para 23).

45. Tests be conducted to define a "production" AH-1G standard airspeed system position error (para 25).

APPENDIX I. REFERENCES

1. Test plan, "Engineering Flight Test of the AH-1G Helicopter (Hueycobra) Phase B," April 1967.

2. Letter, AMSAV-E(EF) to CO, USAAVNTA, SAVTE-P, Subject: "US Army Aviation Test Activity Participation in the AH-1G/XM-28 Airworthiness Qualification Program," 20 October 1967.

3. Unclassified message, AMSAV-E (EF) - 11-1368 to SAVTE-P, subject: "AH-1G/XM-28 Airworthiness Qualification Program," 15 November 1967.

4. Report No. 209-947-016, "Detail Specification for Model AH-1G Helicopter," Bell Helicopter Company, 11 July 1966.

5. TM-55-1520-221-10 "Operator's Manual, Army Model, AH-1G Helicopter, Headquarters, Department of the Army," April 1967.

6. Unclassified message, AMSAV-EF-11-1385, CG USAAVCOM to CO USAAVNTA, subject: "Safety of Flight Release for Phase B Testing AH-1G/XM-28," 28 November 1967.

7. USAAVNTA Final Test Report, "Engineering Flight Test of the AH-1G (Hueycobra) Helicopter, Phase B, Part 1," January 1968.

APPENDIX II.

TEST DATA

FIGURE No. 1

SUMMARY OF PITCH AXIS REACTIONS DURING

XM-28 (TWO GAU-2B/A MINIGUNS) FIRING

AH-1G USA S/N 66-15283

AVG. GROSS WEIGHT	AVG. C.G. STATION	AVG. DENSITY ALTITUDE	ROTOR SPEED	CONFIGURATION
8410 LBS.	199.9 IN.	2100 FT.	324 RPM	INSTRUMENTATION PODS OUTBOARD

NOTES:

1. TURRET IN STOW (ZERO DEGREES) AZIMUTH
2. HIGH RATE OF FIRE WITH FLIGHT CONTROLS FIXED.
3. DENSITY ALTITUDE IS APPROXIMATE.

TURRET ELEVATION

○ FULL UP

□ STOW (ZERO DEG.)

◇ FULL DOWN

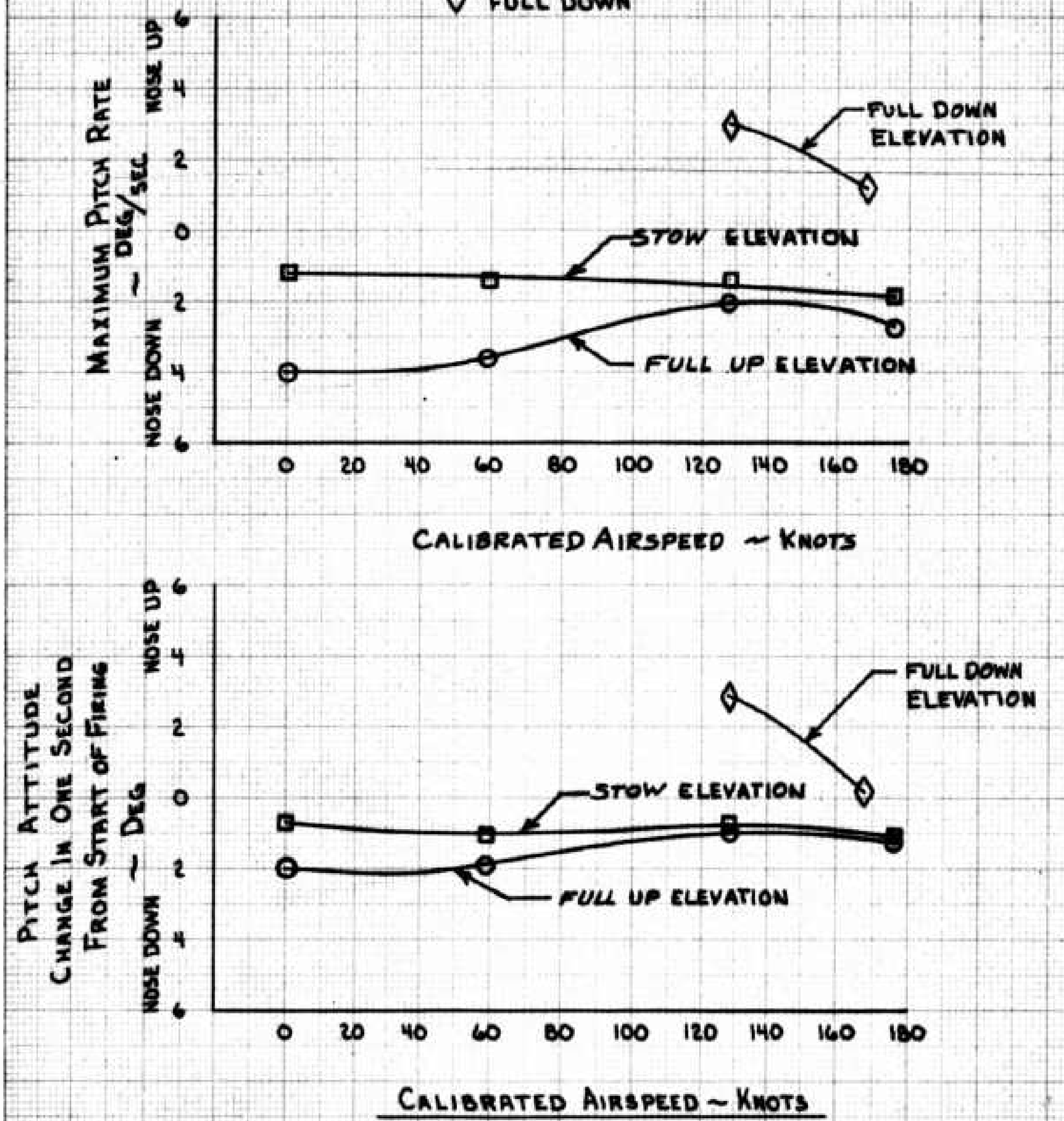


Figure No. 2
SUMMARY OF ROLL AXIS REACTIONS DURING XM-28 (TWO GAU-2B/A MINIGUNS) FIRING

AH-1G U.S.A. S/N 66-15283

AVG. GROSS WEIGHT	AVG. C.G. STATION	AVG DENSITY ALTITUDE	ROTOR SPEED	CONFIGURATION
8410 LBS	199 IN.	2100 FT	324 RPM	INSTRUMENTATION PODS OUTBOARD

NOTES:

1. HIGH RATE OF FIRE WITH FLIGHT CONTROLS FIXED
2. Ø SLASHED SYMBOL DENOTES FULL UP TURRET ELEVATION
3. O FLAGGED SYMBOL DENOTES FULL DOWN TURRET ELEVATION.
4. O OPEN SYMBOL DENOTES STOW TURRET ELEVATION
5. DENSITY ALTITUDE IS APPROXIMATE

TURRET AZIMUTH

O 90 DEGREES LEFT AZIMUTH

◇ 90 DEGREES RIGHT AZIMUTH

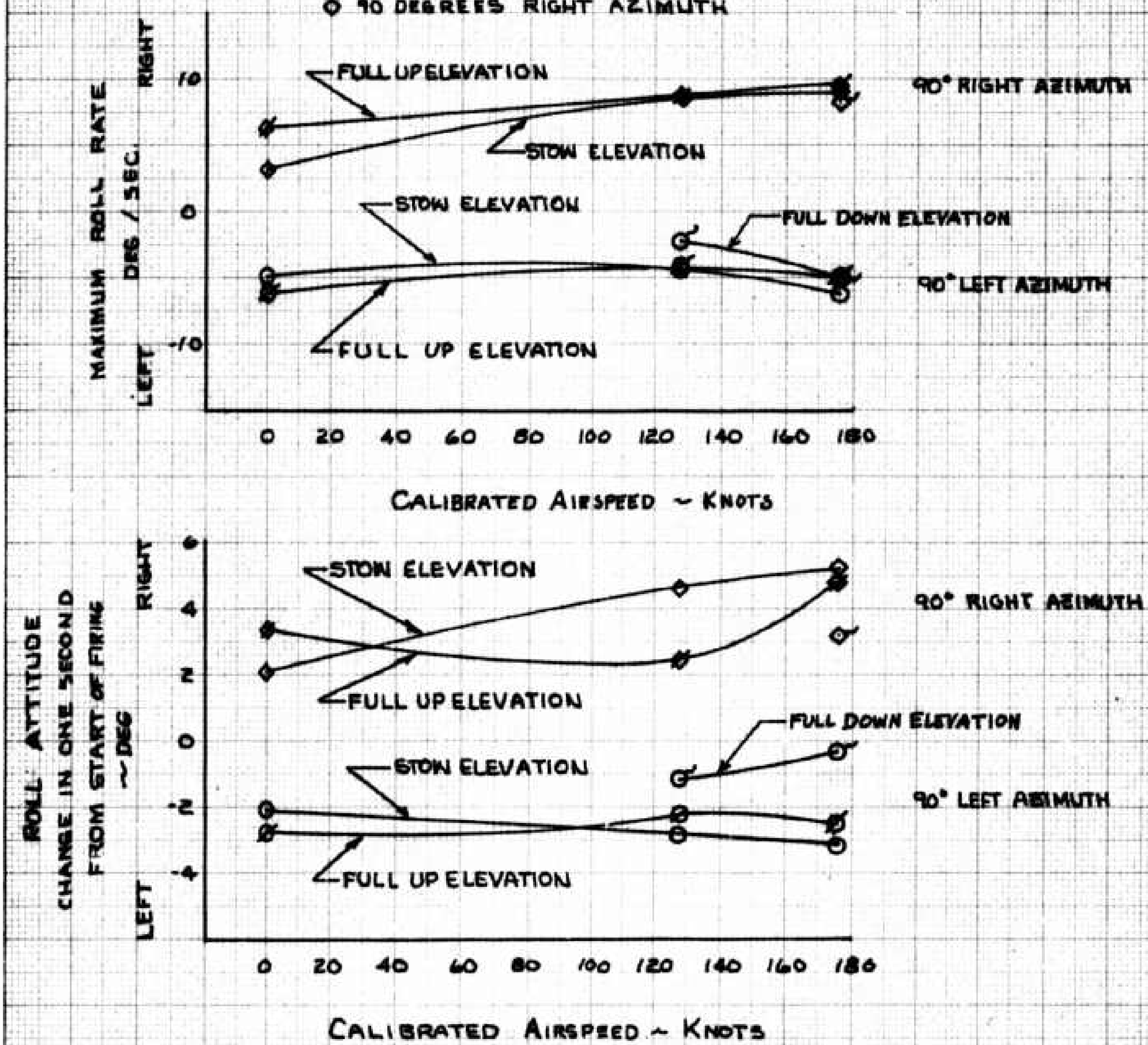


FIGURE No. 3
SUMMARY OF YAW AXIS REACTIONS DURING XM-28 (TWO GAU-2B/A MINIGUNS) FIRING
AH-1G USA S/N 66-15283

AVG. GROSS WEIGHT	AVG. C.G. STATION	AVG. DENSITY ALTITUDE	ROTOR SPEED	CONFIGURATION
8410 LBS.	199 IN.	2100 FT.	324 RPM	INSTRUMENTATION PODS OUTBOARD

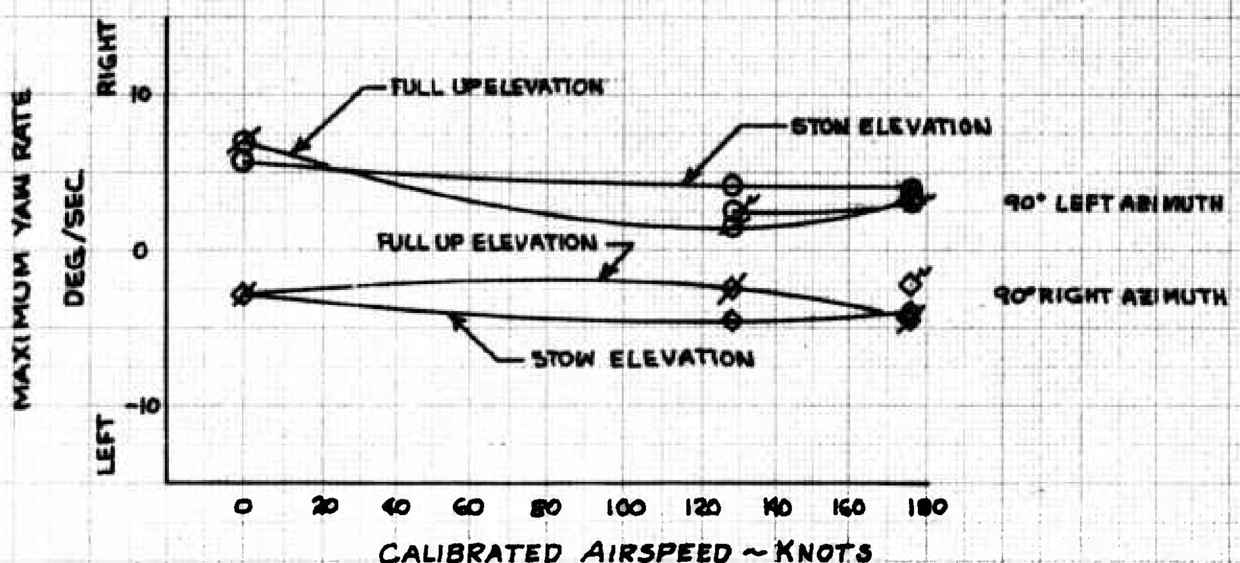
NOTES:

1. HIGH RATE OF FIRE WITH FLIGHT CONTROLS FIXED.
2. Ø SLASHED SYMBOL DENOTES FULL UP TURRET ELEVATION
3. O⌐ FLAGGED SYMBOL DENOTES FULL DOWN TURRET ELEVATION
4. O OPEN SYMBOL DENOTES STOW TURRET ELEVATION
5. *DENSITY ALTITUDE IS APPROXIMATE*

TURRET AZIMUTH

○ 90 DEGREES LEFT AZIMUTH

◇ 90 DEGREES RIGHT AZIMUTH



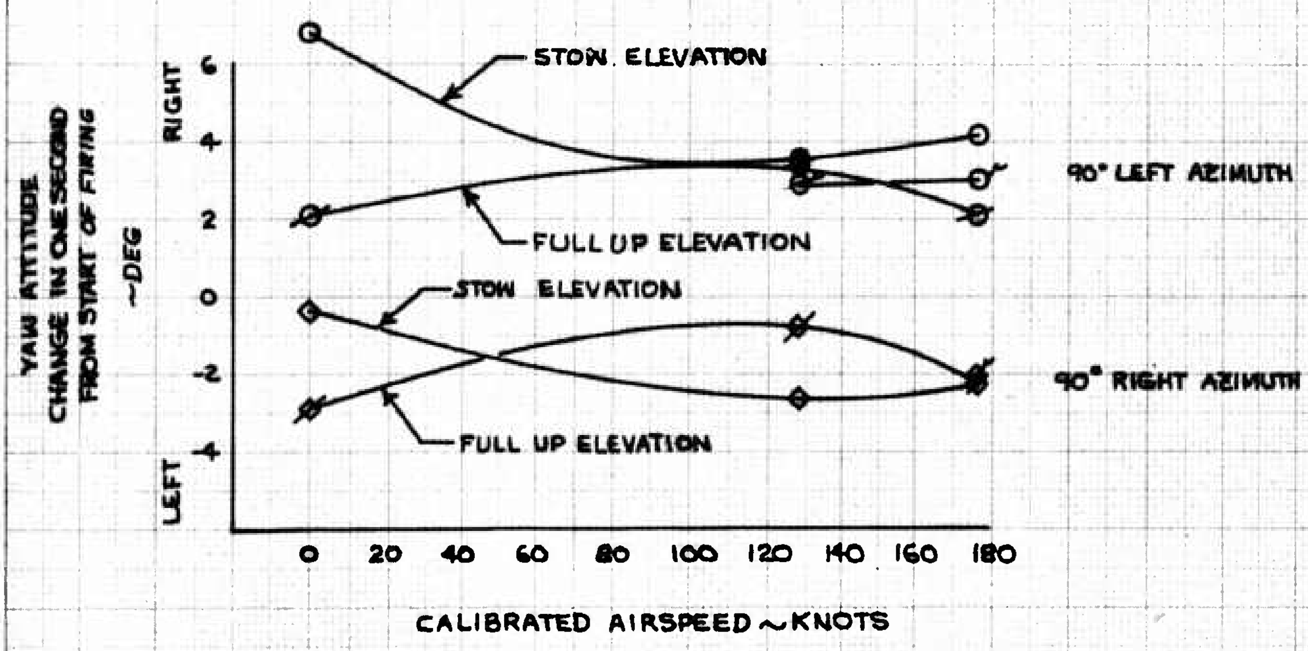
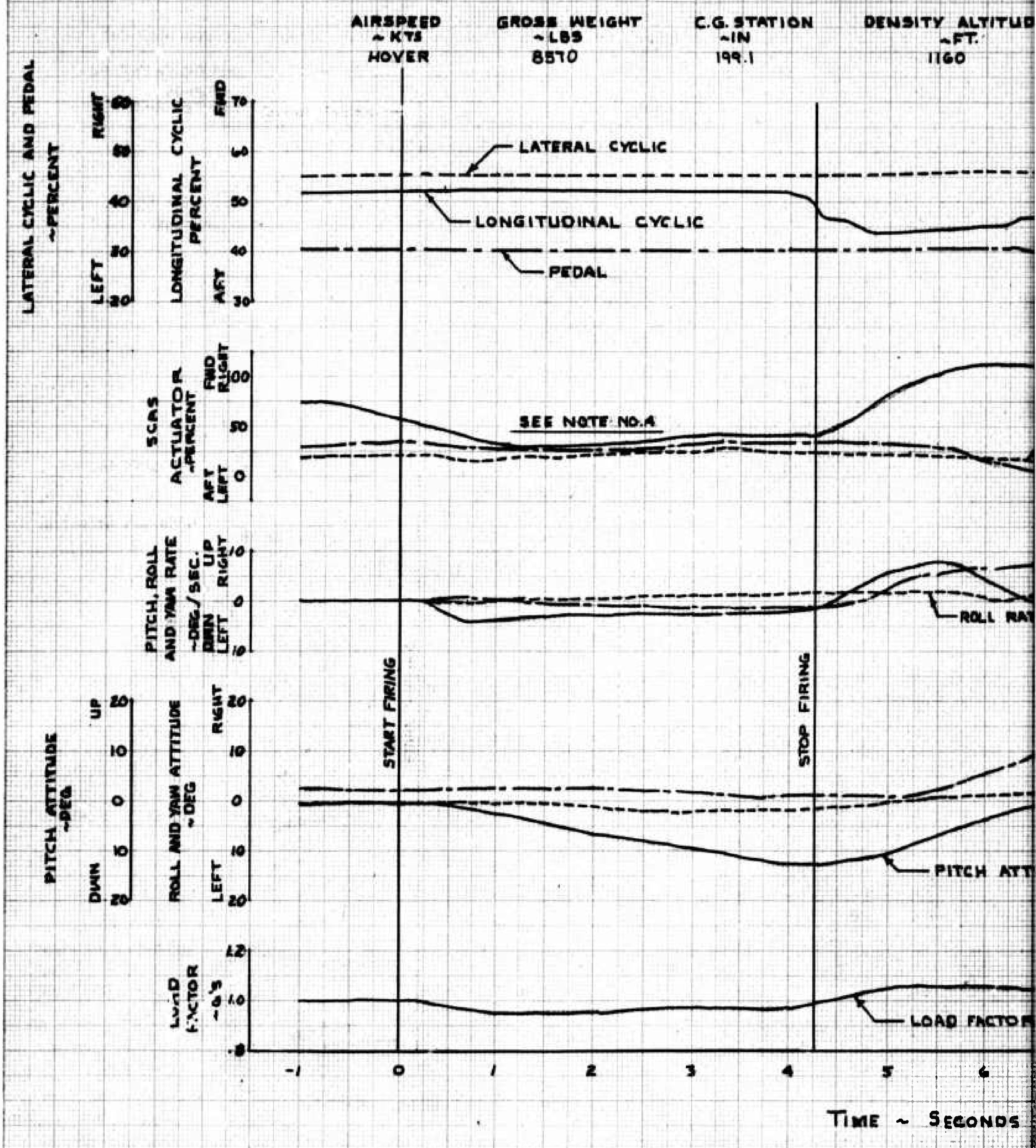


FIGURE No. 4

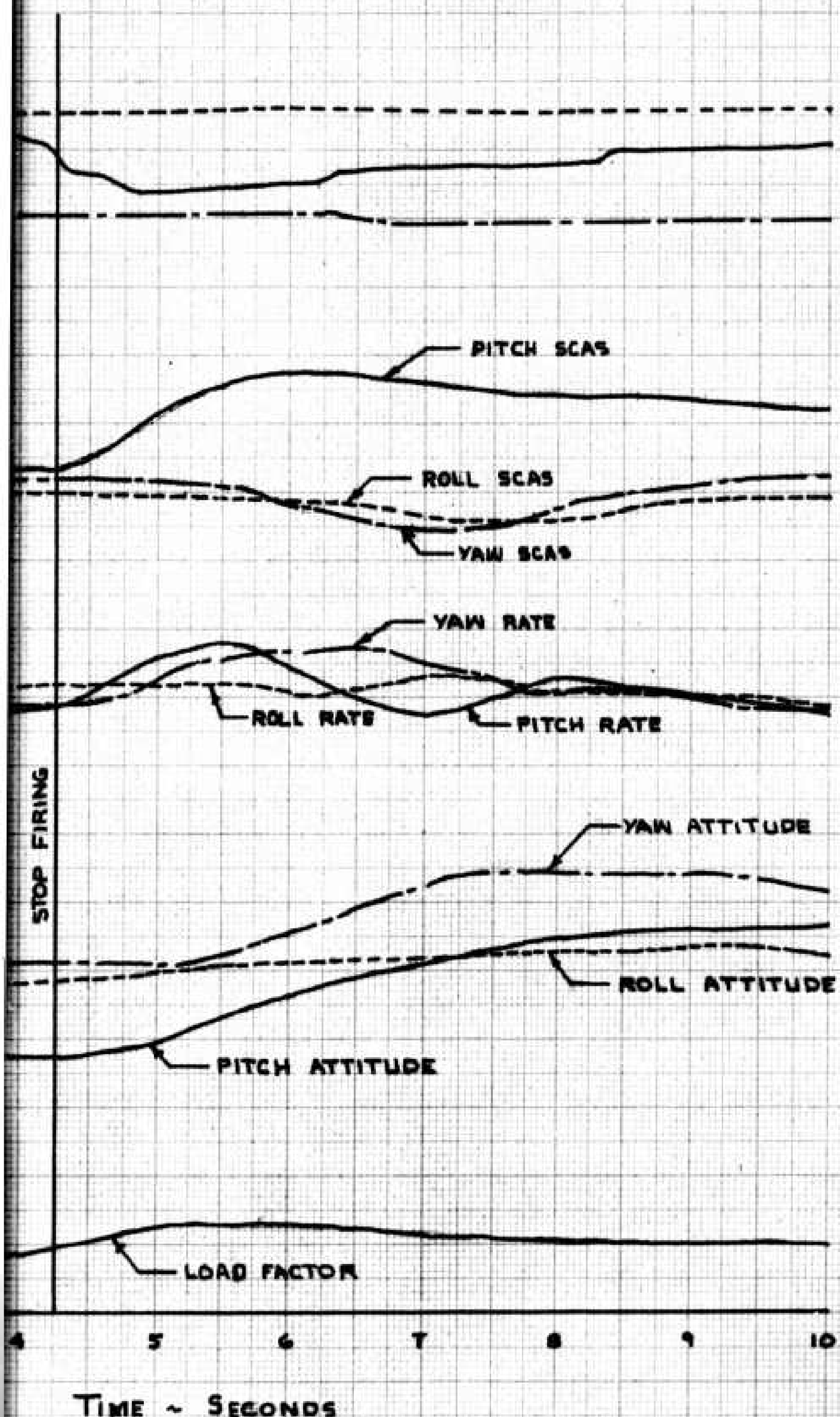
XM-28 (TWO GAU-2B/A MINIGUNS) FIRING

AH-1G USA S/N 66-15283



NS) FIRING

...ON	DENSITY ALTITUDE ~FT.	ROTOR SPEED ~RPM	CONFIGURATION
	1160	324	INSTRUMENTATION PODS OUTBOARD



NOTES:

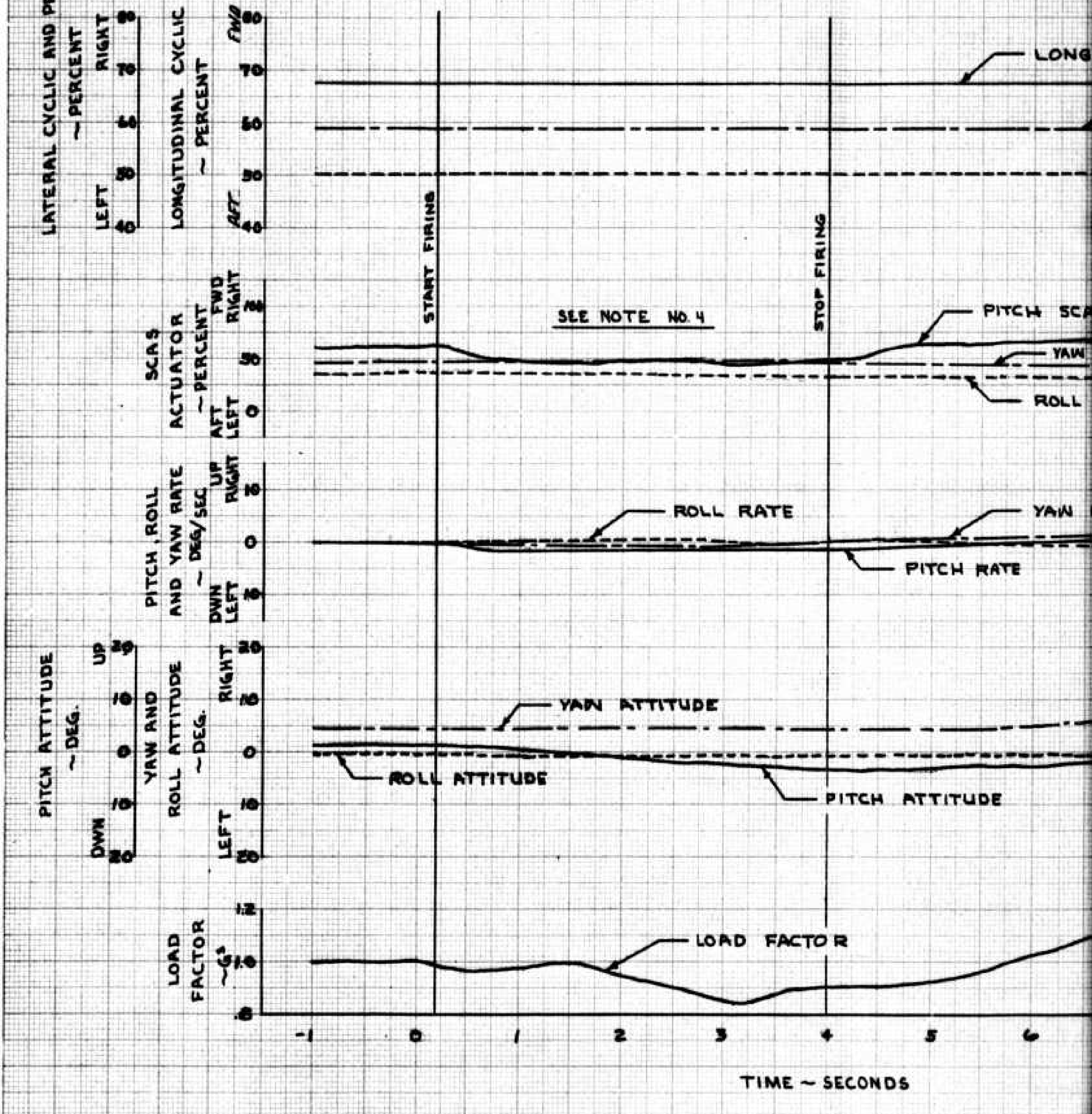
1. TURRET POSITION, ZERO AZIMUTH, FULL UP ELEVATION.
2. BOTH MINIGUNS FIRING HIGH RATE.
3. DENSITY ALTITUDE IS APPROXIMATE, BASED ON UNCALIBRATED FREE AIR TEMPERATURE.
4. SCAS ACTUATOR POSITION INSTRUMENTATION NOT ACCURATE. INFORMATION PRESENTED SHOWS ONLY TRENDS.

FIGURE NO. 5

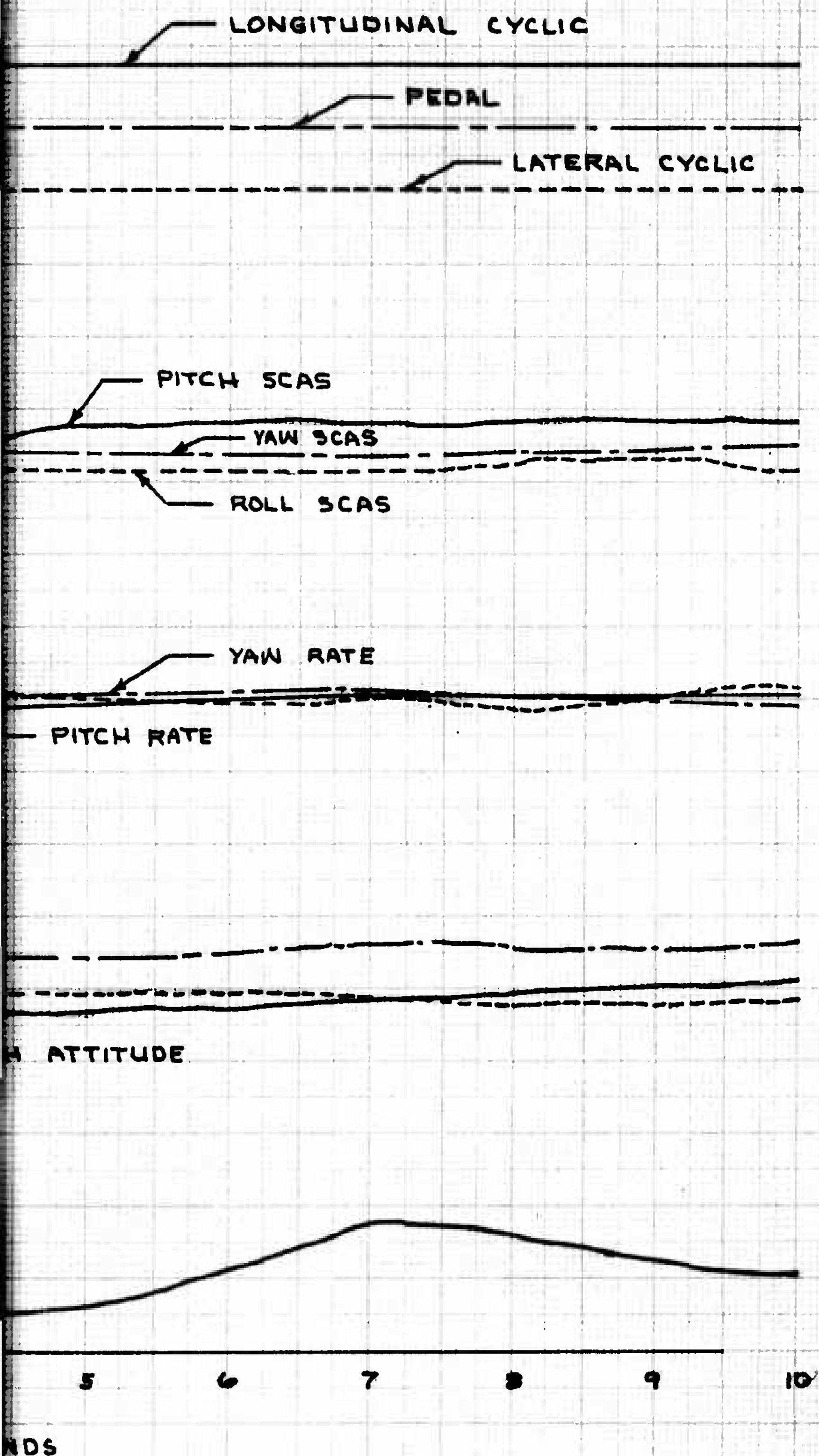
XM-28 (TWO GAU-2B/A MINIGUNS) FIRING

AH-1G USA S/N 66-15283

AIRSPEED ~ KCAS	GROSS WEIGHT ~ LBS.	C.G. STATION ~ IN.	DENSITY ALTITUDE ~ FT.
59.0	8010	202.3	1900



~~NSITY ALTITUDE~~ ~FT.	ROTOR SPEED ~RPM	CONFIGURATION
1900	324	INSTRUMENTATION PODS OUTBOARD



NOTES:

1. TURRET POSITION, ZERO AZIMUTH, ZERO ELEVATION.
2. BOTH MINIGUNS FIRING HIGH RATE.
3. DENSITY ALTITUDE IS APPROXIMATE. BASED ON UNCALIBRATED FREE AIR TEMPERATURE.
4. SCAS ACTUATOR POSITION INSTRUMENTATION NOT ACCURATE. INFORMATION PRESENTED SHOWS ONLY TRENDS.

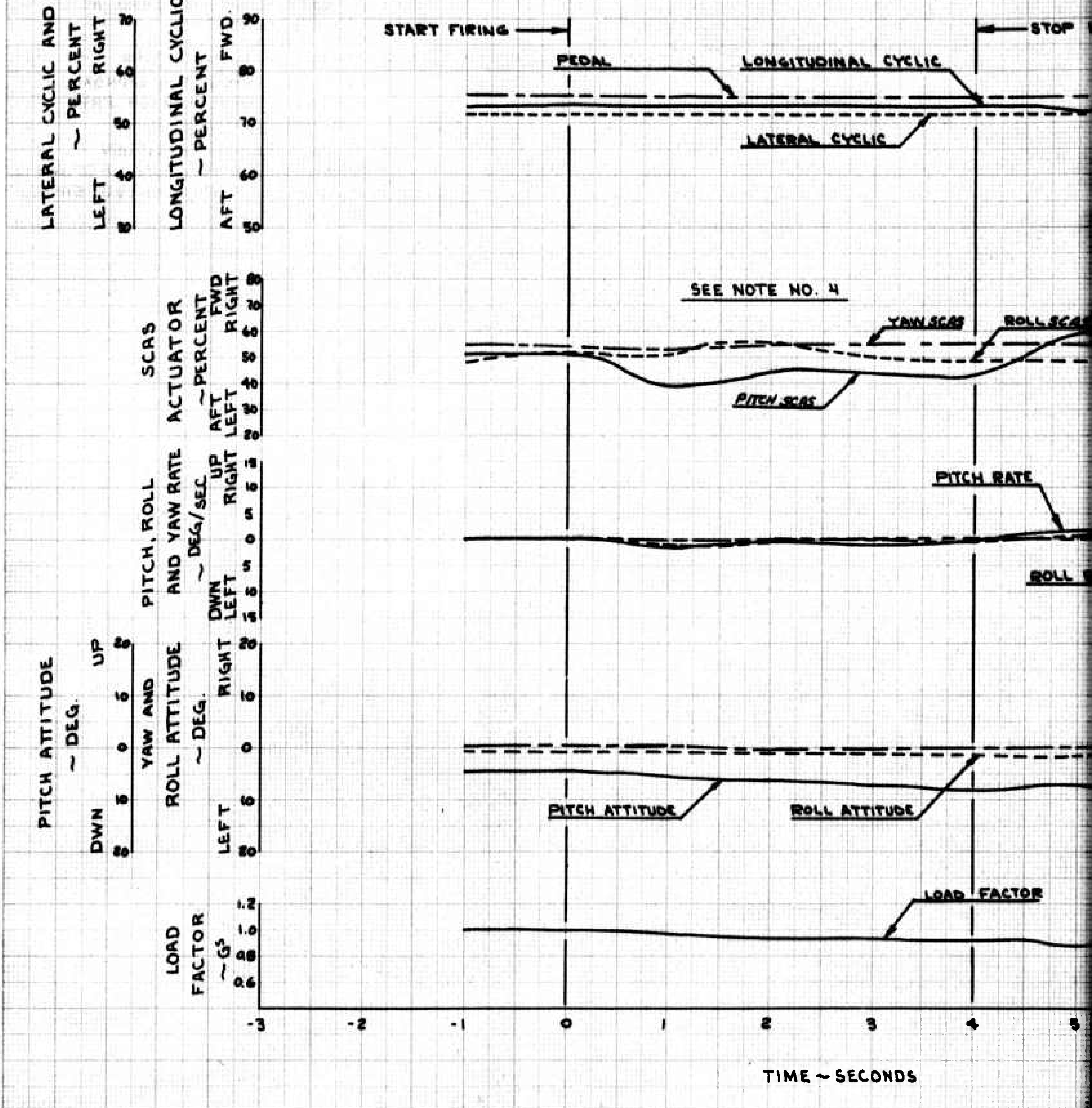
2

FIGURE No. 6

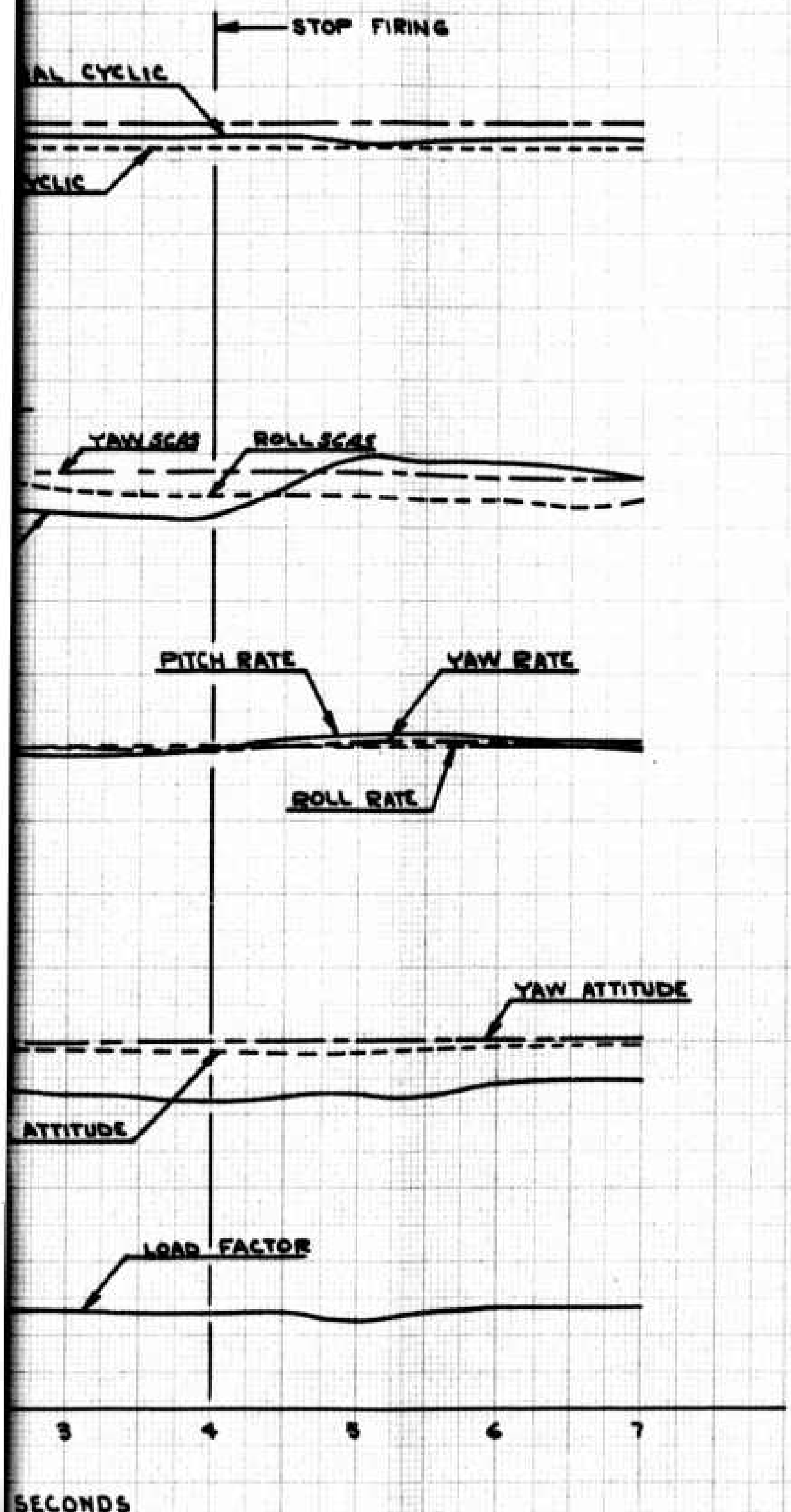
XM-28 (TWO GAU-2B/A MINIGUNS) FIRING

AH-1G USA S/N 66-15283

AIRSPEED ~ KCAS	GROSS WEIGHT ~ LBS.	C.G. STATION ~ IN.	DENSITY ALTITUDE ~ FT.
128.0	8460	199.7	1300



DENSITY ALTITUDE ~ FT.	ROTOR SPEED ~ RPM	CONFIGURATION
1300	324	INSTRUMENTATION PODS OUTBOARD



NOTES:

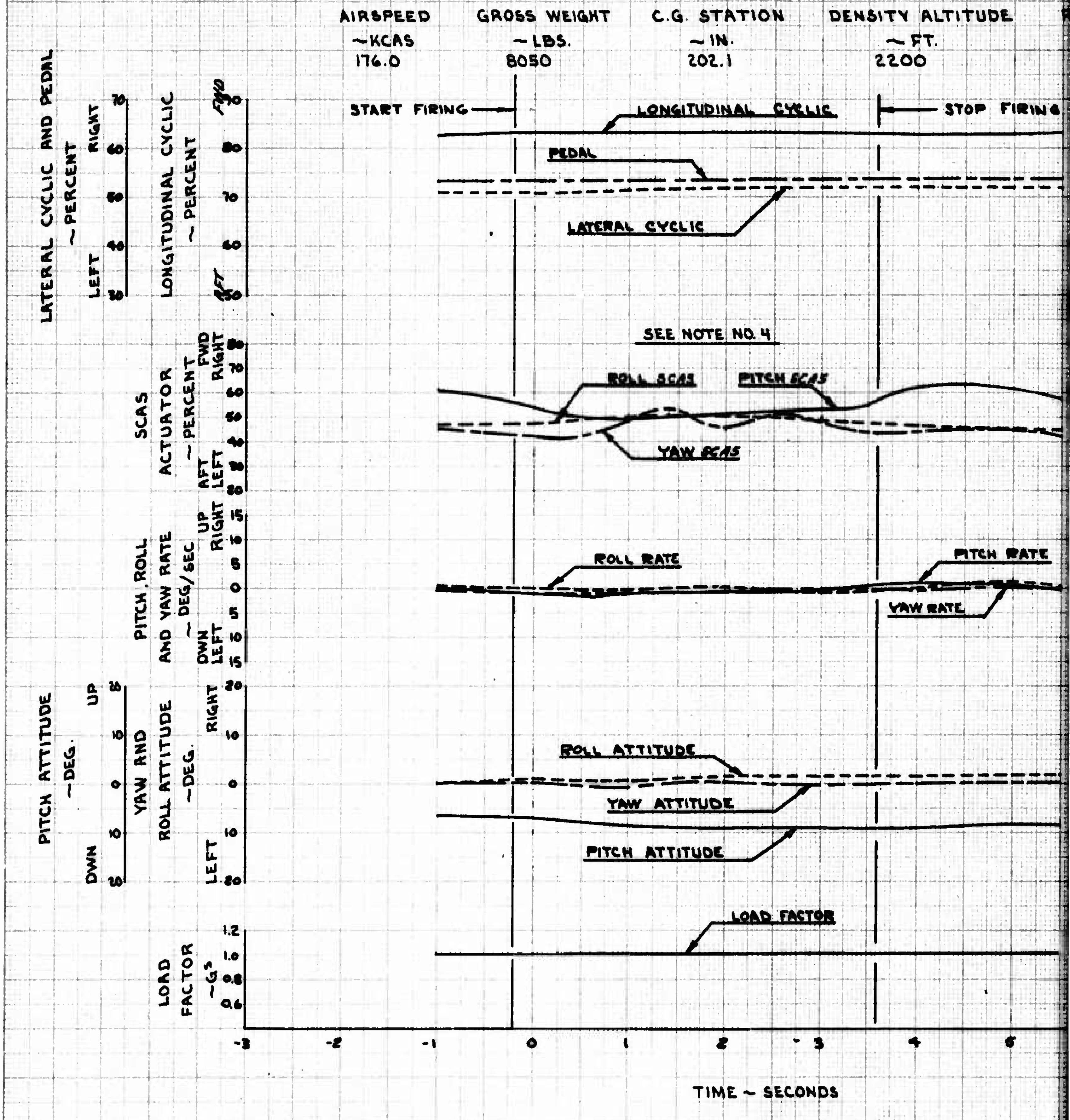
1. TURRET POSITION, ZERO AZIMUTH, ZERO ELEVATION.
2. BOTH MINIGUNS FIRING HIGH RATE.
3. DENSITY ALTITUDE IS APPROXIMATE BASED ON UNCALIBRATED FREE AIR TEMPERATURE.
4. SCAS ACTUATOR POSITION INSTRUMENTATION NOT ACCURATE INFORMATION PRESENTED SHOWS ONLY TRENDS

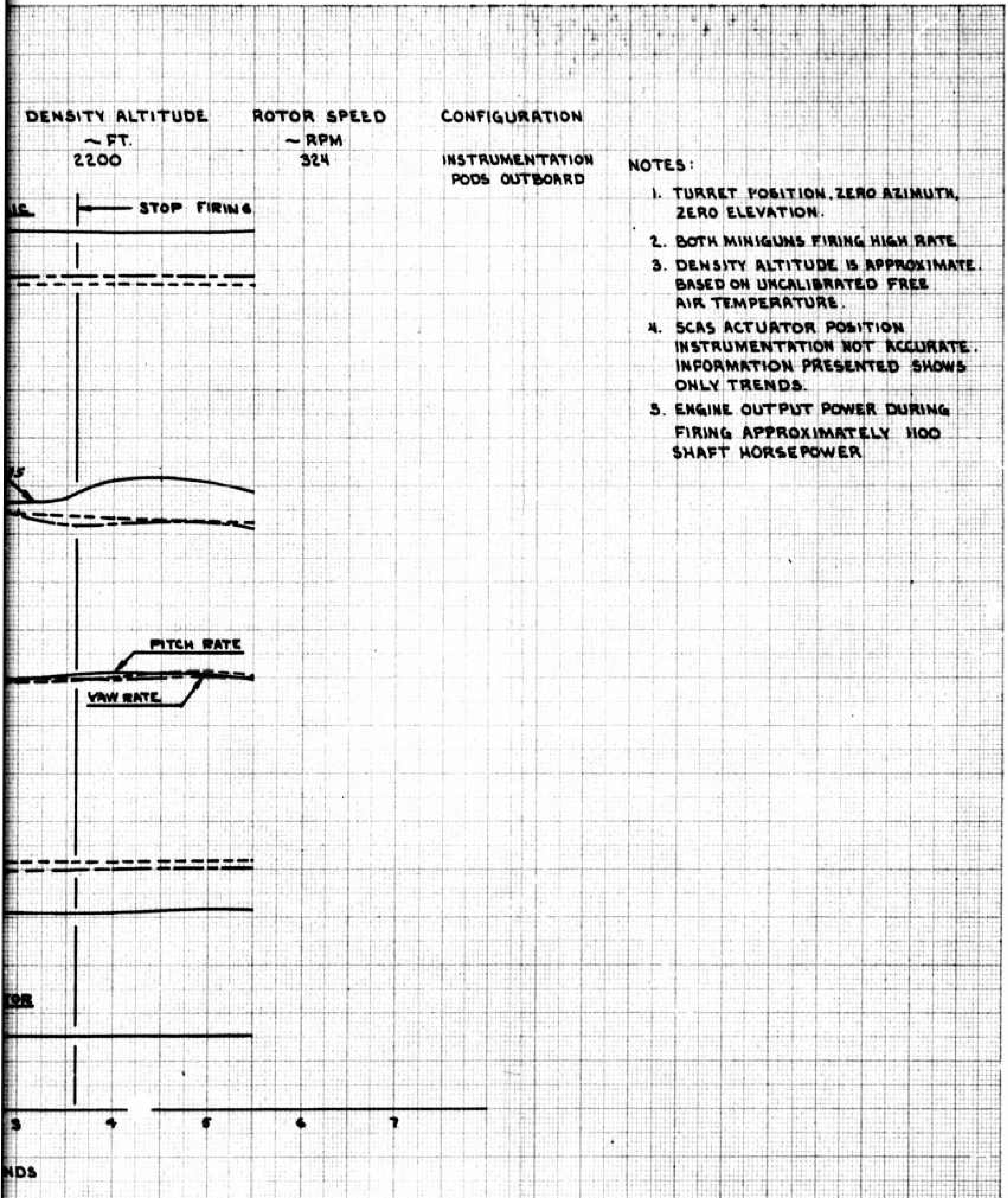
2.

FIGURE NO. 7

XM-28 (TWO GAU-2B/A MINIGUNS) FIRING

AH-1G USA S/N 66-15283



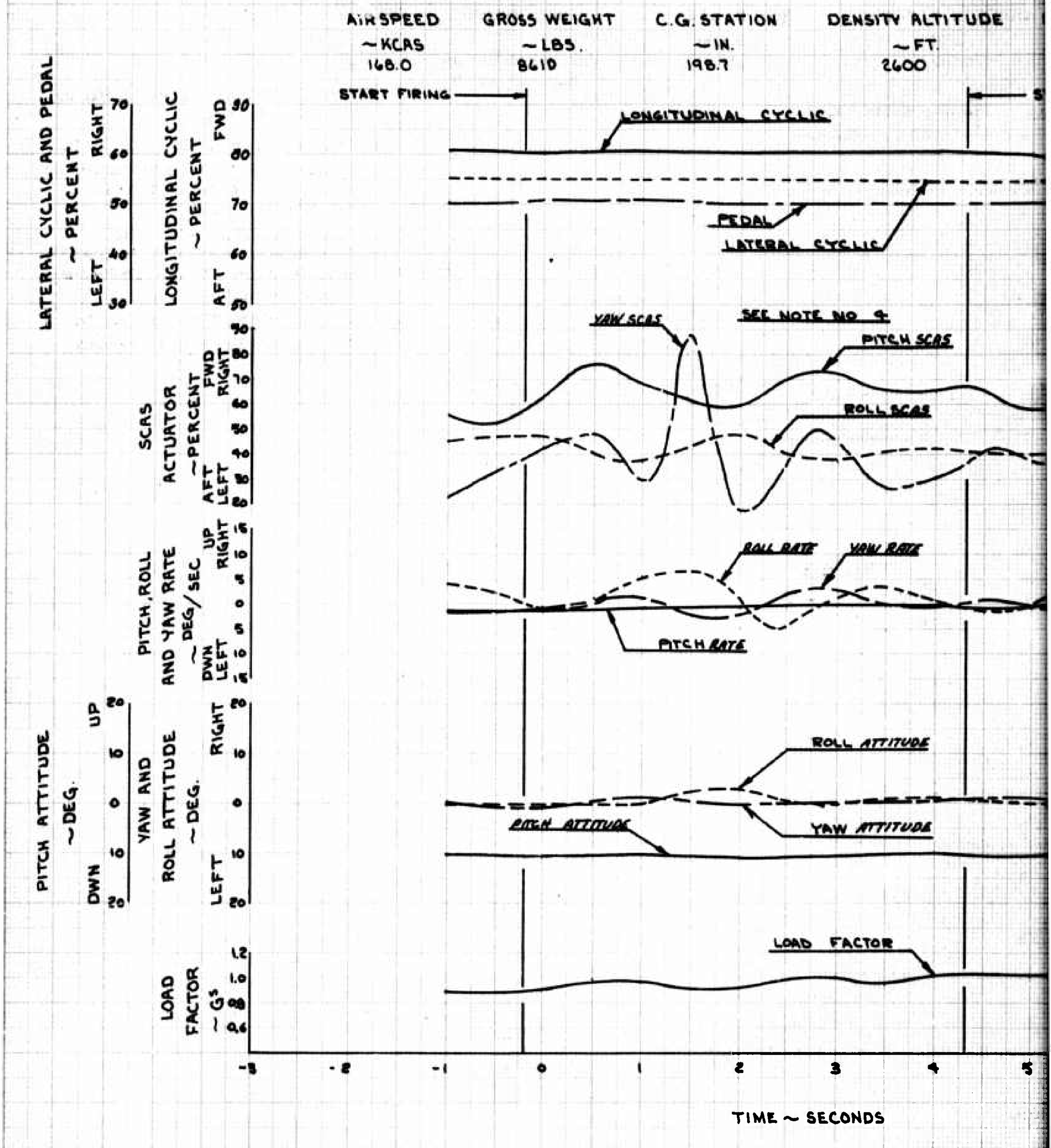

DENSITY ALTITUDE
~ FT.
2200
ROTOR SPEED
~ RPM
324
CONFIGURATION
INSTRUMENTATION
PODS OUTBOARD
STOP FIRING
PITCH RATE
YAW RATE
NOTES:
1. TURRET POSITION, ZERO AZIMUTH, ZERO ELEVATION.
2. BOTH MINIGUNS FIRING HIGH RATE.
3. DENSITY ALTITUDE IS APPROXIMATE. BASED ON UNCALIBRATED FREE AIR TEMPERATURE.
4. SCAS ACTUATOR POSITION INSTRUMENTATION NOT ACCURATE. INFORMATION PRESENTED SHOWS ONLY TRENDS.
5. ENGINE OUTPUT POWER DURING FIRING APPROXIMATELY 1100 SHAFT HORSEPOWER
3
4
5
6
7
NDS

2

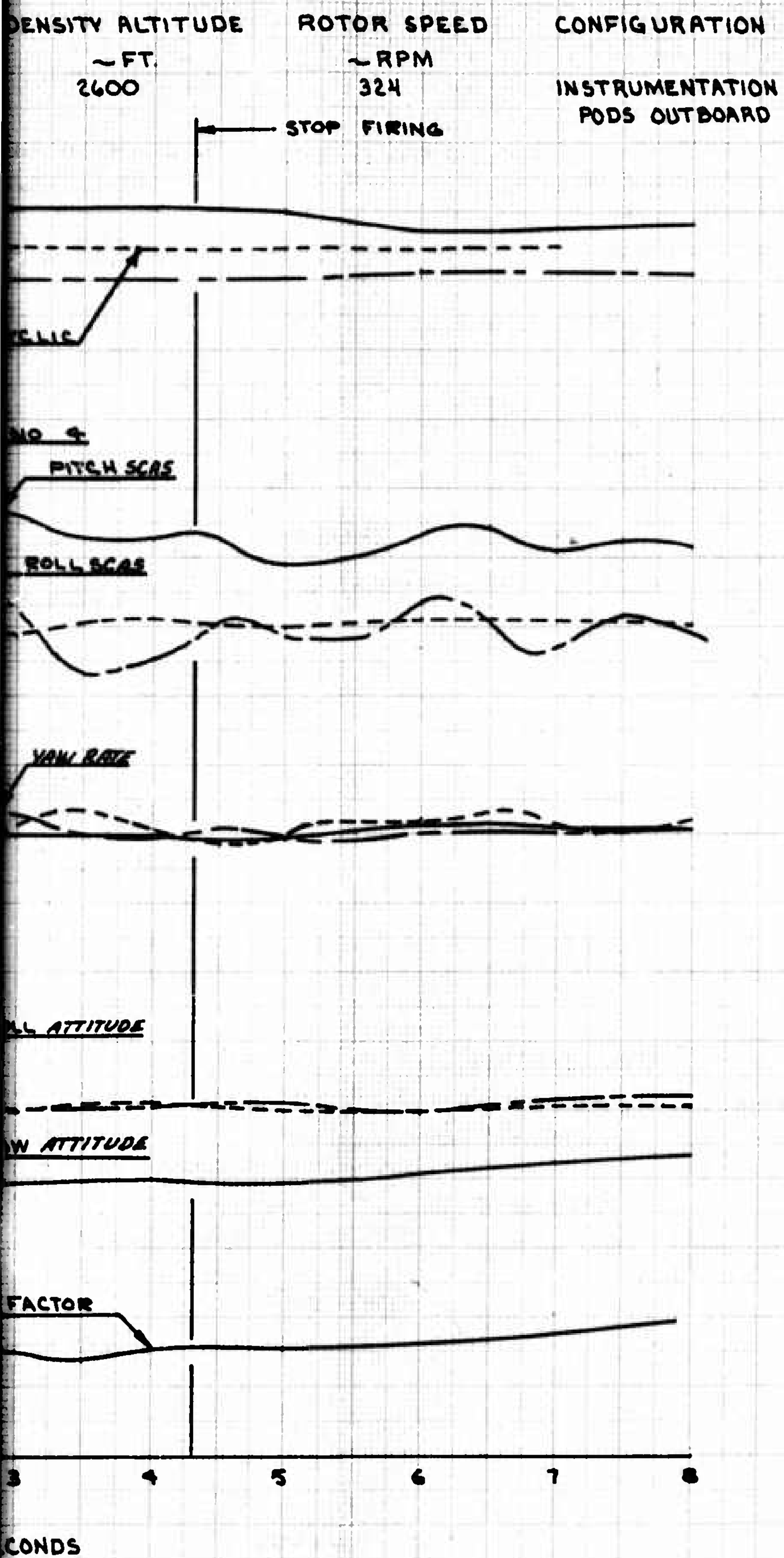
FIGURE NO. 8

XM-28 (TWO GAU-2B/A MINIGUNS) FIRING

AH-1G USA S/N 66-15283



3



NOTES:

1. TURRET POSITION, ZERO AZIMUTH FULL DOWN ELEVATION.
2. BOTH MINIGUNS FIRING HIGH RATE
3. DENSITY ALTITUDE IS APPROXIMATE. BASED ON UNCALIBRATED FREE AIR TEMPERATURE
4. SCAS ACTUATOR POSITION INSTRUMENTATION NOT ACCURATE INFORMATION PRESENTED SHOWS ONLY TRENDS
5. ENGINE OUTPUT POWER DURING FIRING APPROXIMATELY 1100 SHAFT HORSEPOWER

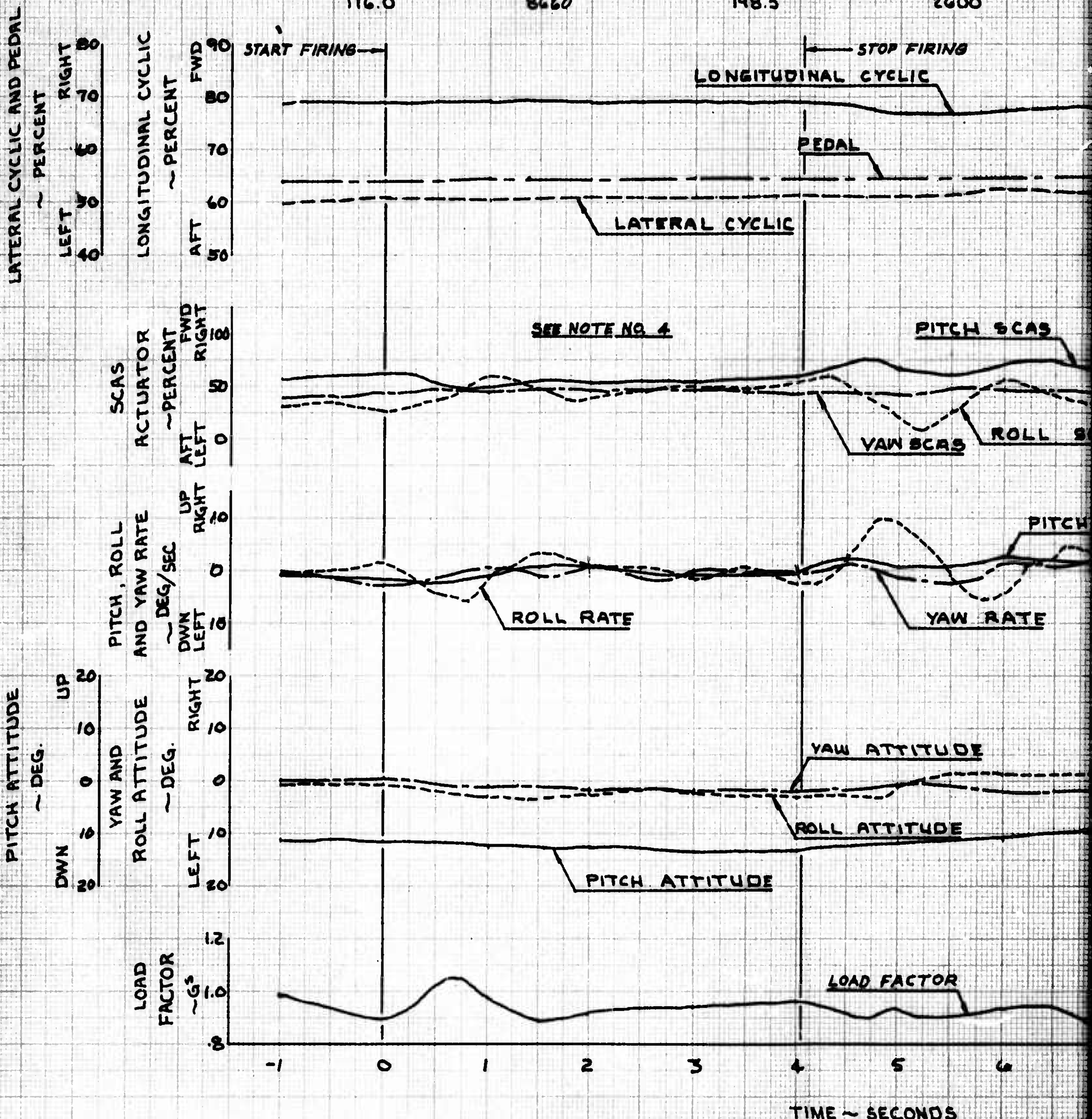
2

FIGURE NO. 9

XM-28 (TWO GAU-2B/A MINIGUNS) FIRING

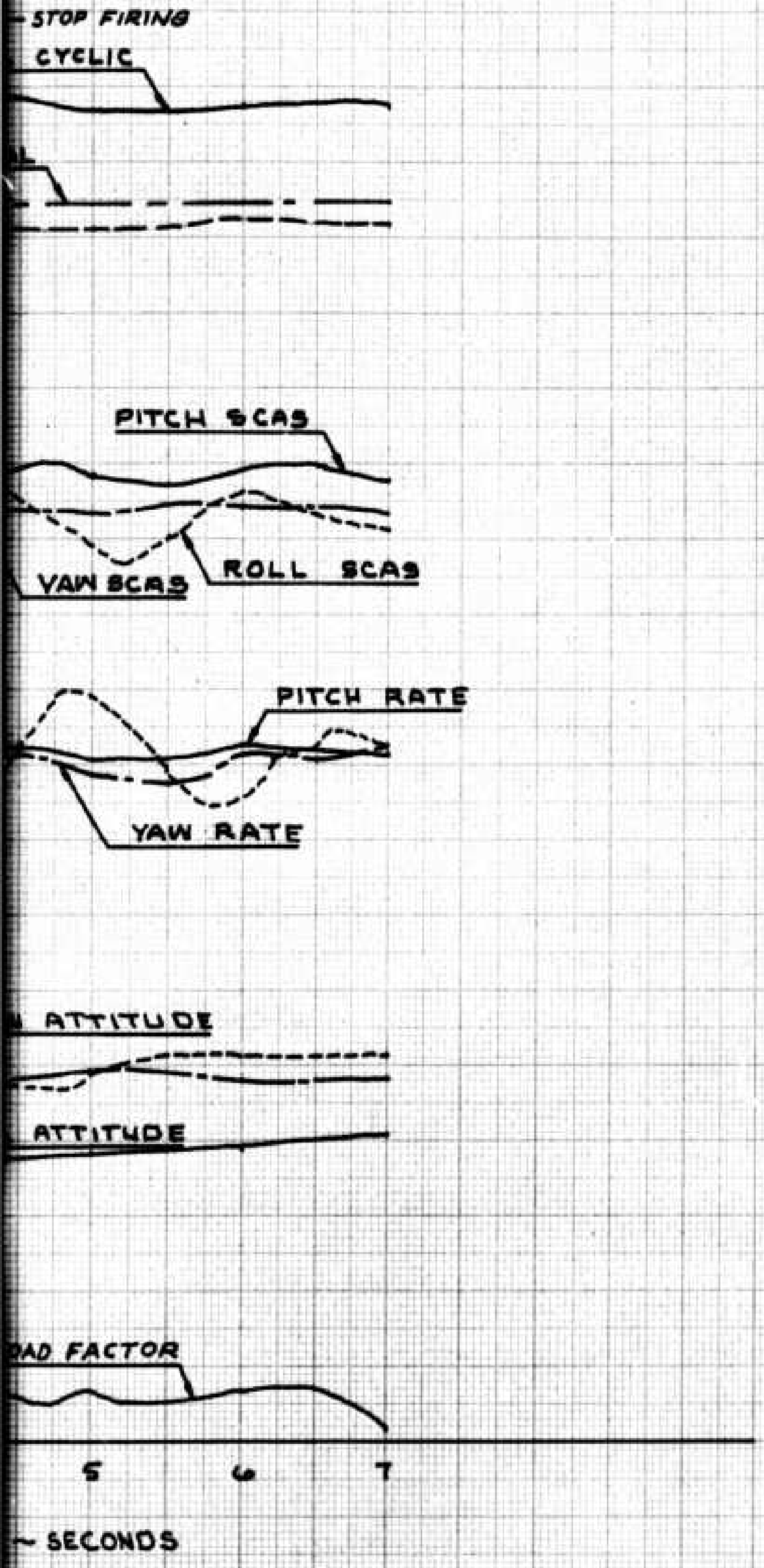
AH-1G USA S/N 66-15283

AIRSPEED ~ KCAS	GROSS WEIGHT ~ LBS.	C.G. STATION ~ IN.	DENSITY ALTITUDE ~ FT.
176.0	8660	198.5	2600



1

DENSITY ALTITUDE ~ FT.	ROTOR SPEED ~ RPM	CONFIGURATION
2600	324	INSTRUMENTATION PODS OUTBOARD

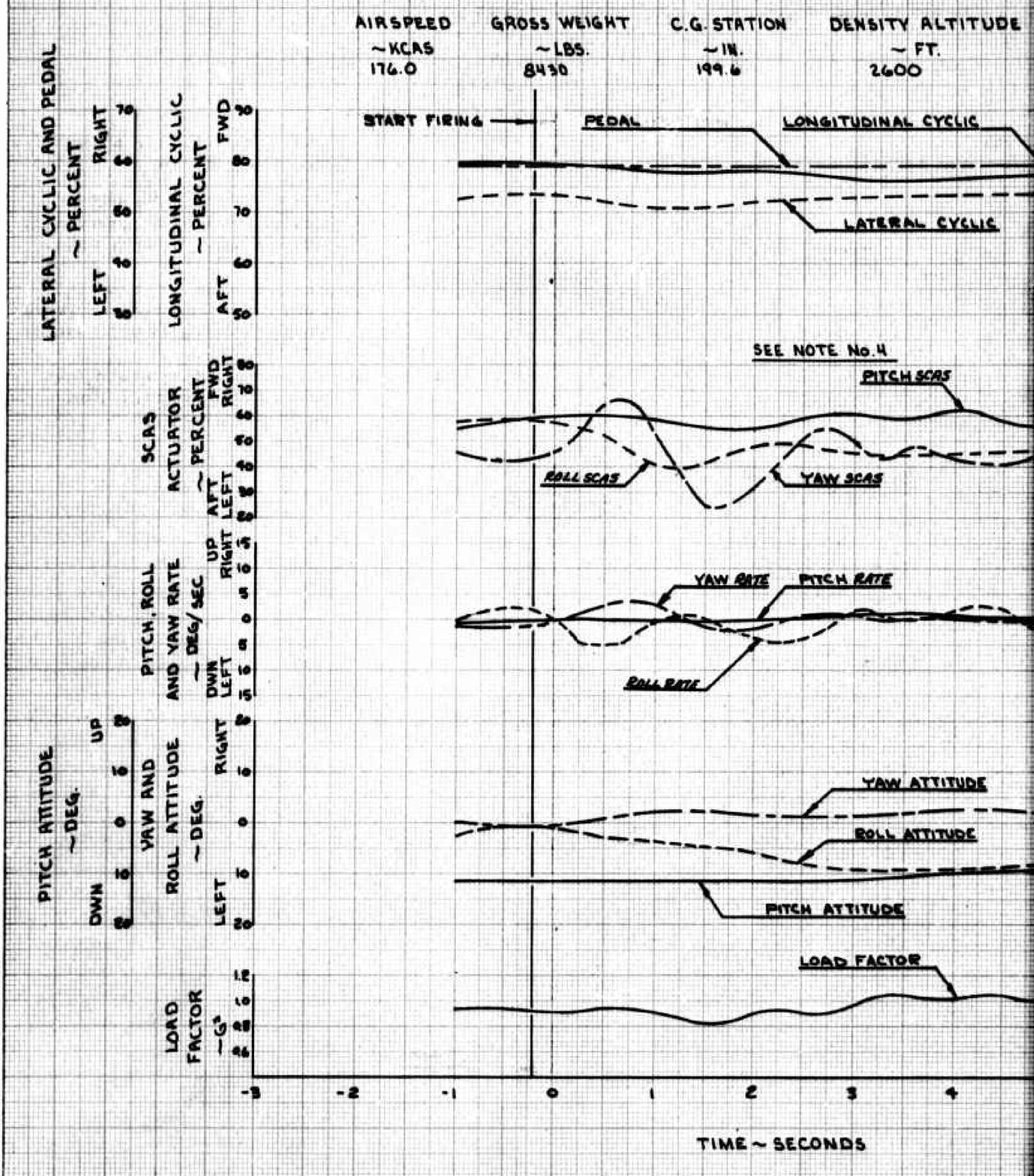


NOTES:

1. TURRET POSITION, ZERO AZIMUTH FULL UP ELEVATION.
2. BOTH MINIGUNS FIRING HIGH RATE
3. DENSITY ALTITUDE IS APPROXIMATE BASED ON UNCALIBRATED FREE AIR TEMPERATURE
4. SCAS ACTUATOR POSITION INSTRUMENTATION NOT ACCURATE INFORMATION PRESENTED SHOWS ONLY TRENDS.
5. ENGINE OUTPUT POWER DURING FIRING APPROXIMATELY 1100 SHAFT HORSEPOWER

2

FIGURE No. 10
XM-28 (TWO GAU-2B/A MINIGUNS) FIRING
AH-1G USA S/N 66-15283



NOTES:

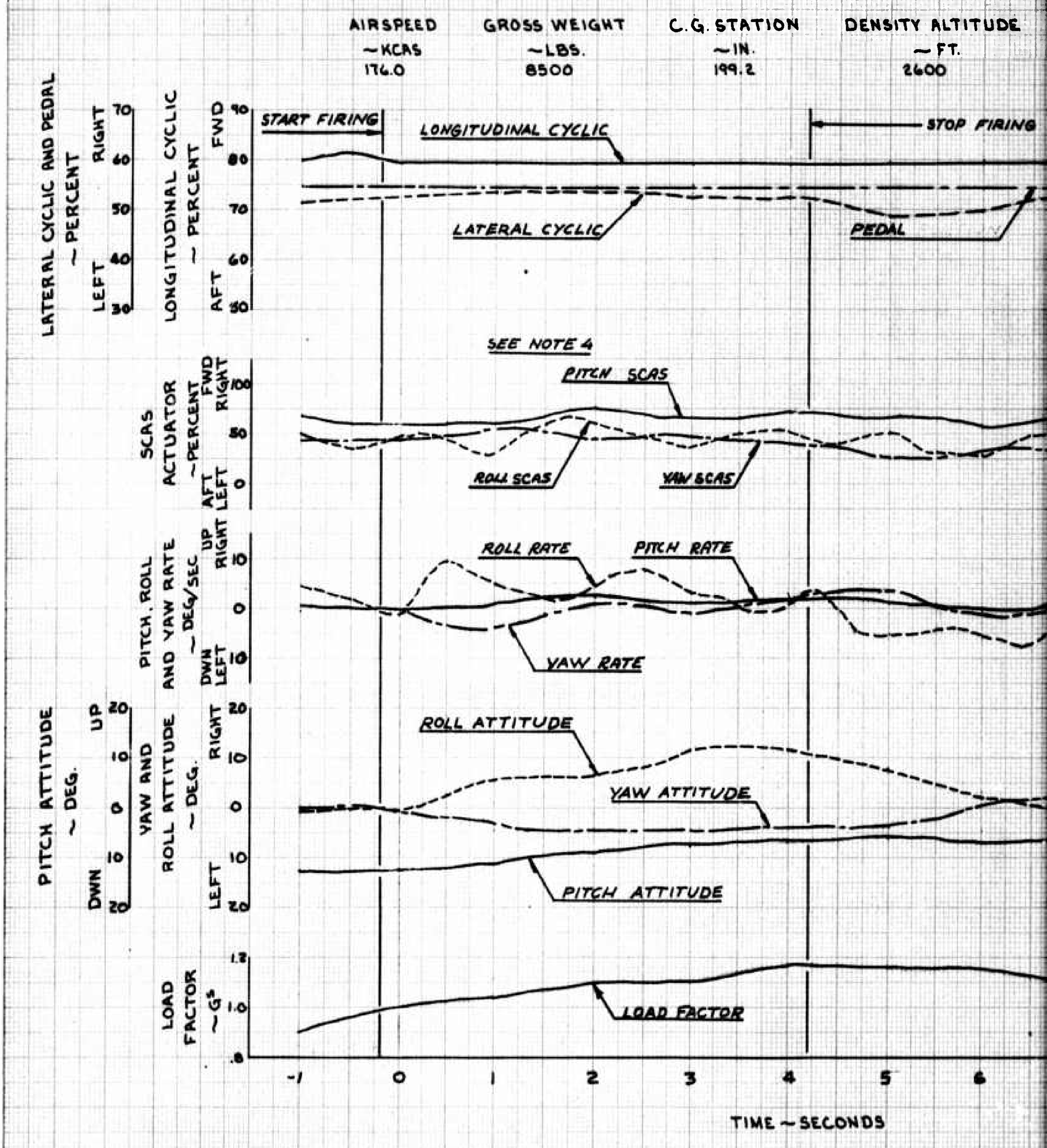
1. TURRET POSITION, 90° LEFT AZIMUTH, FULL UP ELEVATION.
2. BOTH MINIGUNS FIRING HIGH RATE.
3. DENSITY ALTITUDE IS APPROXIMATE BASED ON UNCALIBRATED FREE AIR TEMPERATURE.
4. SCAS ACTUATOR POSITION INSTRUMENTATION NOT ACCURATE. INFORMATION PRESENTED SHOWS ONLY TRENDS.
5. ENGINE OUTPUT POWER DURING FIRING APPROXIMATELY 1100 SHAFT HORSEPOWER

2

FIGURE NO. 11

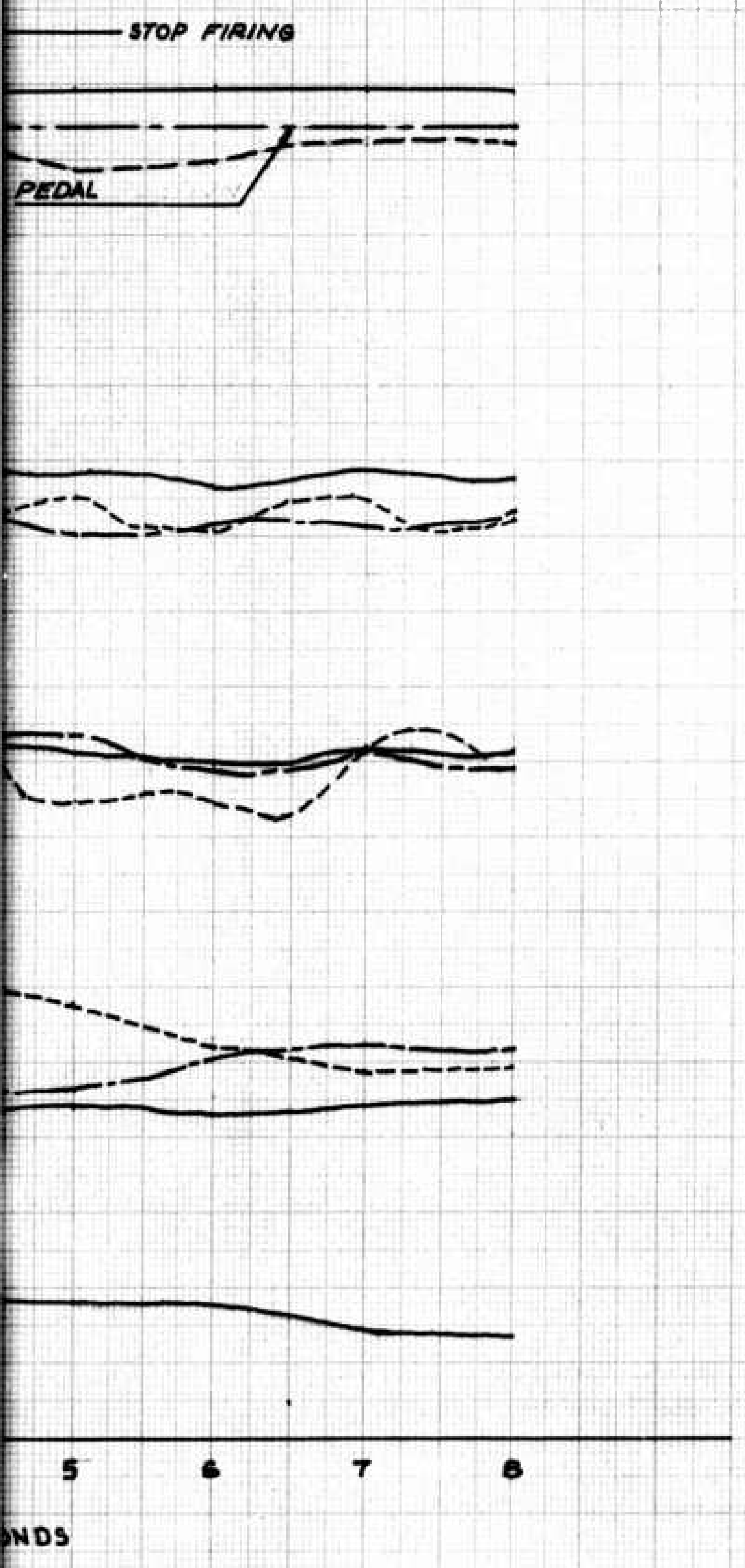
XM-28 (TWO GAU-2B/A MINIGUNS) FIRING

AH-1G USA S/N 66-15283



1

DENSITY ALTITUDE ~ FT.	ROTOR SPEED ~ RPM	CONFIGURATION
2600	324	INSTRUMENTATION PODS OUTBOARD



NOTES:

1. TURRET POSITION, 90° RIGHT AZIMUTH, FULL UP ELEVATION.
2. BOTH MINIGUNS FIRING HIGH RATE
3. DENSITY ALTITUDE IS APPROXIMATE. BASED ON UNCALIBRATED FREE AIR TEMPERATURE
4. SCAS ACTUATOR POSITION INSTRUMENTATION NOT ACCURATE. INFORMATION PRESENTED SHOWS ONLY TRENDS.
5. ENGINE OUTPUT POWER DURING FIRING APPROXIMATELY 1100 SHAFT HORSEPOWER.

2

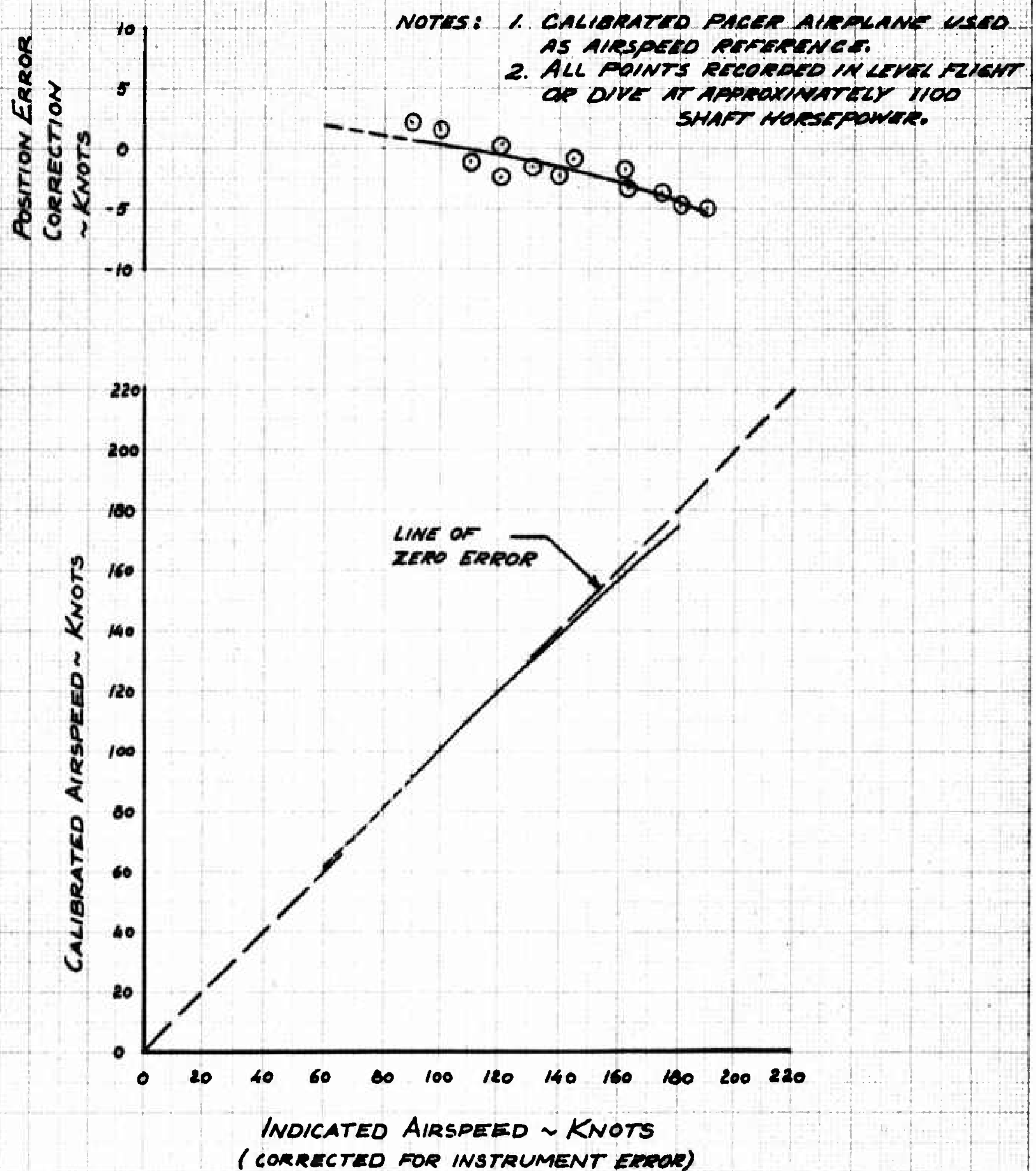
FIGURE No 12

AIRSPEED CALIBRATION

AH-1G USA S/N 6615283

GROSS WEIGHT	C.G. STATION	DENSITY ALTITUDE	ROTOR SPEED	CONFIGURATION
8290 LBS.	199.1 IN.	3100 FT. (AVG.)	324 RPM	INSTRUMENTATION PODS OUTBOARD

STANDARD SYSTEM



APPENDIX III. TEST INSTRUMENTATION

AH-1G HELICOPTER

Serial No. 66-15283

Flight test instrumentation was installed in the test helicopter by the contractor prior to the start of this evaluation. This instrumentation provided data from the pilot's panel, copilot/gunner's panel, and oscillograph. The instrumentation was calibrated by the contractor and approved by the USAAVNTA flight test engineer. The flight test instrumentation was maintained by the contractor throughout the test program. The following parameters were included in the instrumentation package:

a. Pilot's Panel

Standard system airspeed
Standard system altimeter
Collective stick position
"G" force
Oscillograph counter

b. Engineer's Panel

Standard system airspeed
Standard system altitude
Turret azimuth
Turret elevation
Oscillograph counter

c. Oscillograph

Longitudinal cyclic stick position
Lateral cyclic stick position
Collective stick position
Directional control position
C.G. vertical acceleration
Pitch, roll, and yaw attitudes
Pitch, roll, and yaw rates
Copilot/gunner's vertical acceleration
Altitude
Delta torque
Linear rotor speed
Turret position

The following instrumentation was requested, but was either not provided or not calibrated by the contractor:

- Sensitive rotor speed
- Free air temperature
- Longitudinal, lateral and directional SCAS actuator position
- Fuel used

APPENDIX IV. AIRCRAFT DIMENSIONS AND DESIGN INFORMATION

Overall Dimensions:

Aircraft length (rotors turning)	52 ft 11.65 in.
Fuselage length	44 ft 5.20 in.
Maximum fuselage width (including stub wings)	10 ft 11.60 in.
Maximum fuselage width (without stub wings)	3 ft 0 in.
Width of skid gear	7 ft 0 in.
Minimum rotor ground clearance (without flexure)	7 ft 10.00 in.

Main Rotor:

Rotor diameter	44 ft 0 in.
Cord	2 ft 3 in.
Airfoil	symmetrical special 0009 1/3%
Twist	.455 deg/ft
Disc area	1520.4 ft^2
Blade area	49.5 ft^2 per blade
Solidity ratio	0.0651
Preconing angle	2.75 deg
Collective pitch travel	7.29 deg
Longitudinal cyclic travel	± 14 deg
Lateral cyclic travel	± 10 deg

Aircraft Weights:

Empty weight	5516 lb
Test weight range	8010 lb to 8660 lb
Design gross weight	6600 lb
Maximum gross weight	9500 lb

APPENDIX V. AH-IG HELICOPTER OPERATING LIMITATIONS

1. Limit Airspeed (V_L):

   Hog or alternate configuration - 180 KCAS below 3000 feet density altitude. Decrease 8 KCAS per 1000 feet above 3000 feet.

   All other configurations - 190 KCAS below 4000 feet density altitude. Decrease 8 KCAS per 1000 feet above 4000 feet.

2. Gross Weight - Center of Gravity Envelope:

   Forward limit - Below 7000 lb, fuselage station (F.S.) 190, linear decrease from F.S. 190 at 7000 lb to F.S. 192.1 at 9500 lb.

   Aft limit - Below 7650 lb, F.S. 201. Linear decrease from F.S. 201 at 7650 lb to F.S. 200 at 9500 lb.

3. Sideslip Limits: 5 degrees at 190 KCAS. Linear increase to 20 degrees at 60 KCAS.

4. RPM Limits (steady state):

   Power on - 6600 to 6400 engine rpm
   324 to 314 rotor rpm

   Power off - 304 to 339 rotor rpm
   transient lower limit 250 rotor rpm

   Power on during dives and maneuvers 319 to 324 rpm

5. Temperature and Pressure Limits:

Engine oil temperature	93° C
Transmission oil temperature	110° C
Engine oil pressure	25 - 100 psi
Transmission oil pressure	30 - 70 psi
Fuel pressure	5 - 20 psi

6. T53L-13 Engine Limits - Installed:

Normal rated (maximum continous)	625° C
Military rated (30 minute limit)	645° C
Starting and acceleration (5 second limit)	675° C
Maximum for starting and acceleration	760° C
Torque pressure	50 psi

APPENDIX VI. DISTRIBUTION

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US Army Aviation Materiel Command				
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AMSAV-EAC	2	-	2	2
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USMC LnO	1	-	1	1
Aberdeen Proving Ground, Md 21005				

Agency	Test Plans	Equipment Failure Reports	Interim Reports	Final Reports
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Department of Army Army Concept Team in Vietnam APO San Francisco 96384	1	-	-	1
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FTTE Edwards Air Force Base, California 93523	-	-	-	2
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John R. Melton, Project Engineer

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12. SPONSORING MILITARY ACTIVITY
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St. Louis, Missouri 63166

13. ABSTRACT

Part 3 of the AH-1G helicopter Phase B test was conducted at Yuma Proving Ground, Yuma, Arizona from 27 November to 1 December 1967 by the US Army Aviation Test Activity, Edwards AFB, California. Firing tests were conducted to determine the effects on the stability and control characteristics of the AH-1G helicopter caused by firing the twin XM-134 minigun 7.62 machine guns in the XM-28 chin turret. Firing the two XM-134 miniguns in the XM-28 turret does not cause any objectionable aircraft reactions which would restrict the flight envelope. The deficiencies and detected during this test were lack of fire warning system, unreliability of the roll pins on the feeder assembly, use of a quick disconnect on the gun end of the crossover drive, excessive ammunition chute flexure during loading, and requirement to arm weapons to drop smoke grenades. Shortcomings detected during this test were are latches on the ammunition chut adapters which were too small, flex sight interference with gunner's right leg when sight was stowed, functional switches mislocated and unguarded on flex sight, two position trigger switch not sufficiently distinct between high and low rate, cord for headphone jack in pilots cockpit too long, lack of hand holds for rotor hub inspection, insufficient nonskid material on wings, lack of static droop stops, and lack of quick release fasteners for tail rotor gear box and oil cooler inlet fairings.

discussed.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
AH-1G helicopter						
Phase B						
XM-134 minigun						
XM-28 turret						
Aircraft reaction						
Flight envelope						
Fire warning system						
Roll pins						
Crossover drive						
Ammunition chute flexure						
Ammunition chute adapters						
Flex sight interference						
Two position trigger switch						
Hand holds						
Nonskid material						
Droop stops						
Fairings						